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Transactions
Kansas Academy of Science

Volume 47, No. 1 — September, 1944

The Crop Industries of Kansas[1]

L. E. CALL
Kansas State College, Manhattan

In 1942, the state of Kansas produced nearly forty million tons of crop plant material; new material grown chiefly from seed through the combined aid of earth, air, rain and sunlight with the sweat of a good many Kansas farmers thrown in for good measure. In recent years we have become so accustomed to astronomical figures that the enormous volume of this annual plant growth may make little impression on us.

Possibly the magnitude of the numbers given above would mean more if we imagined a vast hollow bin 100 feet wide and 40 feet high, built around the 1200 miles of the state's boundaries and then filled completely with these products of the soil; for it would take such a huge bin to hold them all.

Director Call here discusses in understandable language the utilization of this great volume of plant products and its importance in the state's economy.—THE EDITOR.

The green plant is one of the most remarkable organisms in the world. It has the ability to use solar energy to combine carbon dioxide of the air and water of the soil to form a basic compound from which all other vital organic compounds are formed, although some plants require nutrients of the soil in addition to the basic compound for their formation. The green plant is the only organism capable of accomplishing this marvelous feat[2]. Man, with all of his knowledge of science, has failed to duplicate in the laboratory this accomplishment of the green plant.

The substances used by plants in the production of organic compounds have limited uses in their original state, but the plant

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[1]Contribution No. 79 from the Office of the Director, Agricultural Experiment Station.
[2]This statement disregards the action of a few groups of bacteria. Their activity is primarily of academic interest since the amount of basic compound produced is small.

products manufactured by the green plant from these simple materials constitute the chief sources of world wealth. They provide either directly or indirectly all items of human food and clothing, and they constitute one of the most important sources of raw material for industrial utilization.

The production of organic material by plants is a continuing process. Season after season and year after year the work goes on. Under natural conditions the process proceeds without dimunition. When natural processes are interfered with by man, it is necessary to practice proper methods of soil conservation to maintain productivity.

Plant production constitutes, therefore, a continuing and renewable source of new wealth. At the end of each crop season in Kansas there exists on the farms of the state a new supply of plant material that did not exist before. This material is available to feed livestock, for human consumption, and to be used as a source of raw material for as many different types of industrial processes as the ingenuity of man may devise.

In 1942, the latest year for which we have accurate crop production records, the crop plants grown on the farms of Kansas produced 38,135,000 tons of plant material[3]. This huge yield was newly created material. It did not exist at the beginning of the growing season. It was produced from products that had but little use to man in their original condition. Although 1942 was a favorable year for crop growth in Kansas, production approaching that of 1942 is possible year after year.

Crop plant production represents but a part of the total plant products of the state. It does not include the vegetation produced on native pastures, which at a conservative estimate amounts annually to 17,600,000 tons of dry plant material. Neither does crop plant production include the products of the woodlands and orchards and gardens that make their annual contribution to the welfare of the state.

It is, however, from the plants grown on the cultivated fields known as crop plants that most of the plant material is derived that can serve as an important source of raw materials for industrial use

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[3]Computed from data from the 33d Biennial Report of the Kansas State Board of Agriculture. 1941-1942.

The production of the various kinds of crop plant material for season of 1942 in Kansas was as follows:

	Tons
Wheat	6,202,000
Other cereal grain, including grain sorghums	4,217,000
Flax	51,000
Sugar beets	90,000
Broom corn	2,000
Potatoes	75,000
Soybeans	71,000
Hay, including forage sorghums	5,935,000
Straw, cornstalks, and sorghum stover	21,492,000
Total	38,135,000

Wheat

Wheat is the most valuable crop produced in the state. In years of heavy production, such as 1942, the state produces more than six million tons of wheat and the production seldom falls below three million tons. This product supplies the basic raw material to support two of the leading manufacturing industries of the state—the milling and the baking industries. The state now has 87 flour mills with a daily capacity of 82,075 barrels of flour, the largest production of any state in the Union. The five mills in Kansas City, Missouri, with a daily capacity of 20,300 barrels, process principally Kansas wheat, and if the capacity of these five mills is added to that of the 87 mills of the state, it would make the state's milling production capacity over 100,000 barrels daily. Such production would exceed by nearly 50 per cent the milling capacity of Minnesota, the next most important milling state in the flour milling industry.

The flour produced from wheat provides the chief source of raw material for about 250 commercial bakeries in the state. These bakeries, taken together, constitute one of the important commercial enterprises of Kansas and provide employment for many of our citizens.

Cereal Grains Other Than Wheat

There was a production in 1942 of more than four million tons of cereal grains other than wheat. These products were used chiefly as feed for livestock. The production consisted of about two and a half million tons of corn, three fourths of a million tons of oats, 400,000 tons of barley, and half a million tons of grain sorghum. From the standpoint of industrial use the grain sorghums are the most intriguing. The other cereals are produced more abundantly and probably more cheaply in other regions of this country. Grain

sorghums, however, especially the combine types, are especially well adapted to this section of the United States, for a pound of grain can probably be produced as cheaply, if not more cheaply from grain sorghum in the southern Great Plains than from any other grain produced in this country. Furthermore, grain sorghums have sold in the past at a lower price per pound on the markets of the southwest than other grains considering their composition. The sorghum grains, therefore, under normal conditions offer a price advantage when considered for industrial utilization.

It appears that a new variety of grain sorghum developed at the Fort Hays Branch of the Kansas Agricultural Experiment Station in cooperation with the United States Department of Agriculture, contains starch with properties similar to the root starches. This new sorghum, but recently christened *Cody,* may find an important industrial use for the production of adhesives, glues, and other industrial products for which common starch cannot be substituted. A small industry for the production of these products from sorghum appears most probable.

Flax and Soybeans

There has been a tremendous increase in the production of both flax and soybeans as a result of war demands for all types of oil-producing crops. The production of flax reached 51,000 tons in 1942 and that of soybeans, 71,000 tons. These yields correspond to six times as much flax and more than ten times as many soybeans as were produced ten years ago. The linseed-oil mill at Fredonia in Wilson County, located in the center of the best flax-producing region of the state, has an annual crushing capacity of about one and a half million bushels, or slightly less than the state's production in 1942.

The six soybean processing plants in the state have a daily maximum crushing capacity of 8,000 bushels per day. This capacity is slightly less than that needed to process the crop produced in 1942 if the plants operated at capacity on a 260-day year.

It is doubtful if flax and soybean production will be maintained on their present basis, since Kansas must be considered a somewhat higher cost-of-production area for these crops, especially soybeans, than certain other sections of the country.

Hay, Including Forage Sorghums

The production of hay, including the forage sorghums, in 1942 reached a total of nearly six million tons and was made up of

slightly more than one million tons of alfalfa, somewhat less than a million tons of other tame hay, three fourths of a million tons of wild hay, and about three million tons of forage sorghums. Nearly all of this material is now utilized for feed for livestock—most of it on the farms where the product is produced.

For a number of years a small amount of alfalfa hay has been processed for commercial feeds by grinding, and within the past few years an important industrial development of dehydrating green alfalfa for the production of a highly nutritious ingredient for use in mixed feed has started.

Dehydrated alfalfa production has increased rapidly in the state in the past five years and would have increased more rapidly but for the inability to secure new plant processing equipment. There are at present alfalfa dehydrating plants at 13 places in Kansas, and two additional plants recommended for approval and in process of securing equipment. Information is not at hand as to the total capacity of these plants but it is not less than 18 units with each unit having a daily capacity of 100 tons of green alfalfa hay. Kansas has today less than half the acreage of alfalfa that was grown thirty years ago. There should be no difficulty in expanding the acreage quickly if there were a demand for increased production for dehydrating purposes at a price that would encourage the farmer to grow the crop.

Alfalfa dehydrating plants have dehydrated a small quantity of young cereal grains and some consideration has been given to the dehydration of some of the forage sorghums, but little if any of this material, other than Sudan grass, has been processed up to this time.

The sorghums are used industrially in a limited way for two other purposes. About 2,000 tons of broom-corn brush was produced in 1942. This brush provides the raw material for a number of small broom factories in the state. Sorghum is also grown in limited amounts for the production of sorghum molasses. At one time there was a large sorghum molasses manufacturing plant in the state, but at present all the sorghum utilized for this purpose in the state is processed in small units on the farm.

Straw, Cornstalks, and Sorghum Stover

In 1942, Kansas produced not less than 21 million tons of cereal straw, cornstalks, and sorghum stover. This tremendous quantity of organic material should find a more important use in the economy of the state than it now finds. This large supply of inefficiently used

material should afford a major challenge to all who are concerned with the industrial development and economic welfare of the state.

This material should not be considered, however, entirely as a waste product, since at the present time a small quantity is used as feed and bedding for livestock, a little for industrial purposes, and much is returned to the soil where it decomposes and helps to maintain the organic matter supply of the soil. On the other hand, a considerable quantity of this material is burned and is thus wasted. A part of this crop residue could be used for industrial purposes without endangering the future productiveness of the soils of the state, provided other soil conserving practices were followed.

Yet with this tremendous quantity of organic material, aggregating more than 21 million tons, much of which is now completely wasted, the one straw-board factory in the state has had great difficulty in securing sufficient wheat straw to supply its needs. The problem is not one of basic supply or of the possibility of utilizing the material successfully in the production of useful manufactured products, but is that of discovering and developing methods of collecting and assembling the material with sufficient economy to enable the material to be used in the production of manufactured products in competition with other raw materials. The problem is a challenge to American ingenuity. It is one upon which agricultural engineering research should be directed with the utmost energ immediately upon the close of the war.

Other Crops

Among the other crops produced in the state that provide raw material suitable for industrial use are sugar beets, potatoes, and other vegetables. About 90,000 tons of sugar beets were produced in 1942, chiefly in the Arkansas river valley, and processed by the sugar plant at Garden City.

About 75,000 tons of potatoes were produced in 1942. Potatoes are a valuable source of starch but studies made in Kansas of the possibility of utilizing the potatoes of this state for starch production indicate that the crop probably cannot be used economically for this purpose.

A number of vegetable crops, peas, sweet corn ,and tomatoes, are grown in Kansas for commercial canning. They provide the raw product for two commercial canneries. There appears to be an opportunity for a few more commercial canneries located under favorable conditions in the state.

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VOL. 47, No. 1 SEPTEMBER, 1944

ROBERT TAFT, *Editor*

With this issue the *Transactions* begins publication as a quarterly, a change decided upon after an extensive consideration and correspondence of several months among the members of the Editorial Board and the Academy Council. We are hopeful that this change will arouse greater interest in the work of the Kansas Academy of Science and thus stimulate and invigorate its affairs. The Academy, now in its 76th year of activity, was organized in 1868 with the express purpose of "increasing and diffusing knowledge."

In its quarterly form, the *Transactions* proposes to aid in realizing these objectives by the publication of the scientific studies of its members as it has in the past. In addition, however, we hope to enlarge somewhat the scope of the quarterly *Transactions* over that of the annual *Transactions* by including news of Academy members, reports of Academy activities in the interval between annual meetings, and the inclusion of "Letters to the Editor," which are hereby invited from one and all. The letters may contain comments, additions, corrections, or criticisms of the scientific papers published in the *Transactions;* or, if the correspondent feels so inclined, other criticisms of the Academy and its members —including the editor—may be made. If the flood of criticism becomes too great, however, we may appeal for letters containing a few words of approval.

Quarterly publication, after the system has time to establish itself, will provide for prompt publication of scientific reports by Academy members. To further this desirable end, manuscripts for publication may be submitted to the editor *at any time* during the year. If such reports are published before they can appear on the program of an annual meeting of the Academy, it is suggested that they be entered by title on the program of the annual meeting following publication.

An additional feature which the editor hopes can be utilized in the new form of this publication is the use of a feature article in each issue; a general article which reviews a limited field of scientific knowledge in language which the non-specialist can understand. Such articles should be of interest to those in other scientific fields than the one represented by the subject and to the intelligent layman as well. Our greatest difficulty, of course, will be to find persons who can

write with authority and at the same time with simplicity and clarity. Possibly, if the subjects are at first restricted to topics of Kansas interest, authors will be easier to find. Kansas geography, Kansas weather, the scientific aspects of certain Kansas industries (salt, flour, etc.), reports of experimental work that have contributed to the development of the State, Kansas parks, and general summaries of animal and plant life are among the many topics that suggest themselves. Readers of the *Transactions* having topics that they should like to see reviewed are requested to send in their suggestions to the editor and, what is more important, to suggest possible authors for such general feature articles.

* * *

For the first of these feature articles, we present Dean Call's "The Crop Industries of Kansas."

DEAN L. E. CALL

Leland Everett Call, an agronomist by profession, is an Ohioan by birth and training. However, at a fairly early age he followed Horace Greeley's celebrated advice and came west to Kansas in 1907. Since then he has been intimately and actively concerned in the agricultural development of the State. His Kansas life has all been spent at Manhattan, where, since 1925, he has been Dean of Agriculture of Kansas State College and Director of the Agricultural Experiment Station.

* * *

Cataloguing the flora and fauna of Kansas has been one of the scientific fields most extensively cultivated by Academy members in the 75 years of our history. Reports of these studies, as well as their use, have grown and changed with the years as can be witnessed by the extensive and carefully prepared list of Kansas mammals appearing in the present issue. The first list of such mammals to appear in the *Transactions* was prepared by Professor Knox of Baker University. It will be found in volume 4 of the *Transactions* for 1875. Professor Knox reported that elk, deer and antelope existed in Kansas "in great numbers" at that time. As for bison, "vast numbers roam the western part of the state" but Knox was quick to point out that wanton slaughter was rapidly reducing the great buffalo herds. All of these large mammals are noted as "now extinct" in Dr. Hibbard's list; a change which has occurred in less than seventy years and within the lifetime of

a considerable number of Academy members.

To those of us of the more modern generation, however, museum specimens and "ancient footprints" are all that we shall ever see of those once countless beasts. This great faunal transition, of course, has been of more than local interest for it has been recorded many times, either advertently or inadvertently, in our national literature. There are, for example, Bryant's well-known and eloquent lines:

In these plains
The bison feeds no more. Twice twenty leagues
Beyond the remotest smoke of hunter's camp
Roams the majestic brute in herds that shake
The earth with thundering steps—yet here I meet
His ancient footprints stamped beside the pool.

When Bryant wrote these lines after a visit to the Illinois prairie the great herds were actually nearer than "Beyond the remotest smoke of hunter's camp"; now they cannot be found this side of the happy hunting ground.

* * *

Kansans who lived thru the nightmarish summer of 1934 and the spring of the great dust which followed the next year, may wish to forget all about dust storms; but meteorological history, unfortunately, has a way of repeating itself and the future will surely bring these same phenomena again. The suggested classification of dust storms in the paper by B. Ashton Keith, beginning on page 95, again directs attention to this important problem. Although all meteorologists may not agree with the interpretation of Mr. Keith's experiments, the paper should serve the very useful purpose of stimulating further work and the reconsideration of these tremendously important phenomena. Incidentally, the photographs of dust storms, secured by Mr. Keith from the U. S. Soil Conservation Service, have been called by Mr. S. D. Flora, U. S. Weather Observer for Kansas, "among the most interesting I have seen."

* * *

Every member of the Academy who is a college teacher or administrator will find food for thought in Professor Reed's article in the current issue, "Why Do Some Colleges Reach a Higher Level of Achievement Than Others?" Although Dr. Reed admits he does not have all the answers, he has raised a question that deserves careful and genuine consideration. Possibly a cooperative series of tests in all the colleges of the State would bring additional answers to light.

We trust that the high rank the *Transactions* gives *Harper's Magazine*, through the medium of the Reed article, will be properly appreciated by *Harper's*. The editor, however, is somewhat amazed to see that a college faculty includes *Wild West* and *True Story* in the list of "cultural" magazines. Evidently the editor will have to extend the scope of his reading if he wishes to keep up to date in his education. Possibly the publishers of these two cultural magazines may be willing to help out by responding with a year's subscription to each.

The first regular scientific paper in the quarterly *Transactions* is Dr. Zinszer's presidential address, "Famous Early American Observatories"; this number one position is a logical and deserved honor for our hard-working past president. We have few members who have labored as faithfully and as intelligently in the interests of the Academy as has Dr. Zinszer since he joined our ranks in 1930. The editor was particularly interested in Dr. Zinszer's paper as it crosses trails that the editor pursued in the preparation of his own presidential address in 1933. The material contained in "Famous Early American Observatories" Dr. Zinszer hopes to include eventually in an extensive monograph on American observatories

* * *

Do you like the new form of the *Transactions?* Drop the editor a post card expressing your opinion. It will take but a moment and will be an expression of your interest in the work of the Academy—and helpful to the Editorial Board. Any suggestion, comments or news items can, of course, be added if you are so inclined. If you like the present issue, show it to the editor of your local paper, call it to the attention of the science teachers in your local high school and to all others who might be interested in the Kansas Academy of Science.

My advice to every teacher less experienced than myself would be, therefore: Do not fret over details you have to omit; you probably teach altogether too many as it is. Individuals may learn a thing with once hearing it, but the only way of teaching it to a whole class is by enormous repetition, representation, and illustration in all possible forms. . . . President Allen of Jefferson College says that his instruction has been successful in proportion as it has been elementary. It may be a humiliating statement, but it is one which I have found true in my own experience.—Oliver Wendell Holmes after thirty years teaching experience, most of it in Harvard Medical School.

SCIENTIFIC NEWS AND NOTES OF ACADEMY INTEREST

Dr. J. A. Trent, for the past three years associate editor of the *Transactions,* has resigned his position as professor of biology at Kansas State Teachers College, Pittsburg. He is now head of the science division of Oklahoma Baptist University, Shawnee, Oklahoma.

Dr. Roger C. Smith, professor of entomology and head of the department of entomology at Kansas State College at Manhattan, has been on leave since the middle of February. He is at present Professional Allocation Specialist in charge of the roster of biologists and certain phases of agriculture. Dr. Smith, a past president of the Academy, was also secretary for a number of years. Dr. Ralph Parker is acting head of the department of entomology during Dr. Smith's absence.

Dr. Elvira Weeks, for many

years a member of the chemistry staff at the University of Kansas, has resigned her position and is now research associate at the Kresge - Hooker Scientific Library, Detroit, Michigan.

Dr. J. Howard McMillen, associate professor of physics at Kansas State College, Manhattan, is on leave. He is engaged in war research at Princeton University, Princeton, New Jersey.

Dr. Stuart M. Pady, associate editor of the *Transactions*, returns to his duties this fall as professor of biology at Ottawa University. For the past year, Dr. Pady has been serving as plant pathologist for the U. S. Emergency Plant Disease Prevention Survey, with headquarters at Manhattan. During Dr. Pady's absence from Ottawa University, Professor W. B. Wilson, past president of the Academy, was called from retirement to reassume the duties of professor of biology.

Dr. Earl H. Herrick, professor of zoology in charge of endocrinology and a member of the Experiment Station Staff at Kansas State College at Manhattan, has been on research leave at Ohio State University, Columbus, Ohio. Dr. Herrick was granted the Elizabeth Clay Howald Fellowship for the past year. Dr. Herrick returned to Manhattan on July 1, 1944.

During the past summer Dr. F. C. Gates, Kansas State College, Manhattan, for many years the editor of the *Transactions*, and Dr. H. B. Hungerford, University of Kansas, have both been serving on the staff of the University of Michigan Biological Station, Cheboygan, Michigan.

Dr. Harvey Zinszer, immediate past president of the Academy and professor of physics and astronomy at Fort Hays Kansas State College, is now on leave. He is assisting in the preradar course for army and navy officers at Cruft Laboratory, Harvard University.

Professor H. H. Lane, head of the department of zoology at the University of Kansas since 1923, retired from administrative duties on July first of the present year but will continue to teach. Dr. E. R. Hall, formerly of the department of zoology at the University of California, succeeded Dr. Lane as head of the department.

Mr. Paul V. Imes, for the past four years chemistry teacher in the Hutchinson Public Schools, has become chief chemist for the Carey Salt Company, Hutchinson, succeeding L. E. Enberg, a former member of the Academy. Mr. Enberg is now associated with Merck and Company of Chicago.

Dr. A. B. Cardwell, associate editor of the *Transactions* and professor of physics and head of the physics department at Kansas State College, Manhattan, has been on leave since June 1, 1944. Dr. Cardwell is doing civilian war work with the Clinton Engineer Works, Tennessee Eastman Corporation, Knoxville, Tennessee. Professor L. E. Hudiburg, associate professor of physics and assistant dean of the School of Arts and Sciences, is

acting head of the physics department during Dr. Cardwell's absence.

Dr. R. C. Moore, director of the State Geological Survey, is absent on leave in Washington, D. C. Major Moore is in the Quartermaster Corps of the U.S.A., and is engaged in problems dealing with oil and gasoline supplies.

Dr. Carrell H. Whitnah, assistant professor of chemistry at Kansas State College, Manhattan, is absent on leave to do nutrition work with the United States Army. The last word from Captain Whitnah was that he was stationed at San Luis Obispo, California.

The following resignations from the staff of Fort Hays Kansas State College have been announced: Professor Margaret H. Haggart, department of home economics; Dr. Donald Johnson, assistant professor of psychology; and Dr. C. T. McCormick, professor of mathematics.

Dr. H. W. Marlow, assistant professor of chemistry at Kansas State College at Manhattan has been absent on leave since July, 1942. Dr. Marlow is Major Marlow somewhere in Australia and is doing work in nutrition with the United States Army.

Dr. Paul Murphy, associate editor of the *Transactions* and acting head of the psychology department of Kansas State Teachers College, Pittsburg, has been absent on leave during the past summer serving as research associate on a psychological project under way at the radio training section of the Army Service Forces Training Center at Camp Crowder, Missouri. Dr. Murphy will return to Pittsburg this fall.

Dr. R. K. Nabours, professor of zoology and head of the zoology department and member of the Agricultural Experiment Station staff at Kansas State College, Manhattan, retired on July 1, 1944 as head of the department and is devoting his time to research. Dr. Nabours has been head of the zoology department since 1912. Dr. J. E. Ackert, professor of zoology and dean of the Graduate School will be the head of the department.

Dr. Claude W. Hibbard of the University of Kansas and Mr. Elmer S. Riggs, honorary curator of Dyche Museum, spent part of the summer in the field gathering museum materials in certain paleontological areas of Meade County.

Dr. J. Wilbert Chappell, formerly associate professor of chemistry at Fort Havs Kansas State College is now professor of chemistry at Madison College, Harrisonburg, Virginia.

Miss Margaret Newcomb, associate professor of botany at Kansas State College at Manhattan, has been absent on leave since June 1, 1944, to do research in botany at Indiana University, Bloomington, Indiana. Professor Newcomb holds a research fellowship at Indiana.

Dr. E. H. Taylor, professor of zoology at the University of Kansas, is absent on leave. He is working in a civilian capacity with the U. S. Army and is now overseas.

Mr. Henry J. Peppler, instruc-

tor in bacteriology at Kansas State College at Manhattan, has been absent on leave since September 1, 1942. Mr. Peppler is Captain Peppler with a United States Army Hospital unit somewhere in England.

Dr. H. T. U. Smith, assistant professor of geology, University of Kansas, is on leave and working on problems concerned with military geology. He is with the U. S. Geological Survey in Washington.

Dr. P. S. Albright, formerly professor of physics at Southwestern College, Winfield, is now teaching at Wichita University.

Mr. Marvin J. Twiehaus, instructor in bacteriology at Kansas State College, Manhattan, has been absent on leave since May, 1942. Mr. Twiehaus is a major in the armed services with a hospital unit somewhere in the South Pacific.

Dr. A. W. Barton, professor of biology at Fort Havs Kansas State College is on leave. Dr. Barton is doing research connected with the manufacture of penicillin at Cincinnati, Ohio.

Dr. H. H. Hall, professor of biological sciences at Kansas State Teachers College, Pittsburg, and past president of the Academy, has been appointed director of the newly established Museum of Natural History at the College. An interesting account of the Museum will be found in the March issue of the *Kansas Teacher.*

Charles H. Lockhart, instructor in zoology at Kansas State College, Manhattan has been away on leave since September 1, 1942. Mr. Lockhart was a reserve officer when called into army service. He is Captain Lockhart and is a commander of a coast artillery battery somewhere in England.

Professor Frank Byrne, associate professor of geology and paleontology, Kansas State College, Manhattan, has been absent on leave since September 1, 1942. Professor Byrne is Captain Byrne, teaching in the United States Army Air Corps School at San Angelo, Texas.

Dr. W. J. Baumgartner, managing editor of the *Transactions,* and professor of zoology at the University of Kansas, retires from active duty at the University after 40 years of service.

Professor James S. Allen, associate professor of physics at Kansas State College at Manhattan, has been absent on leave since September 1, 1942. Professor Allen is at work on problems of radiation concerned with the promotion of the war.

Dr. George Kelly, associate professor of psychology at Fort Hays Kansas State College, is absent on leave for military service.

Professor Ernest K. Chapin, associate professor of physics at Kansas State College, at Manhattan, is on leave. He is with the Shure Acoustical Manufacturing Company, Chicago, Illinois.

Dr. R. E. Bugbee, associate professor of zoology at Fort Hays Kansas State College is absent on leave and is doing research at Indiana University.

Every member of the Academy is hereby appointed a reporter for this column. If you are engaged in some unusual or

special research study, if you receive a promotion or change your position, be sure to report the news to the editor or to any member of the editorial board. If you have first-hand knowledge of scientific interest or activities involving persons other than yourself please report such news as well. This column, if all members will cooperate, should be one of the main features of interest in the quarterly *Transactions.*

The resourcefulness and ingenuity of the western farmer in the face of climatic hazards is one of the most remarkable features of the process of adaptation to prairie-plains environment. Injury to crops or even disaster only stimulated efforts at new experimentation. Cotton was grown as far west as Geary county during the early sixties, and was listed in 1864 with misplaced enthusiasm as among the proven drouth resistant crops. Tobacco took its turn in experimentation, but only for short time. Gipsy rice corn was offered as a never failing crop, making a big yield and superior to buckwheat for bread. . . . Sweet sorghum was more successful and was an important crop because of the syrup made from it irrespective of its forage value for livestock. . . . Hungarian grass and millet received a following for tame hay. Although not grown in large quantity, buckwheat was one of the most important staple crops in the eastern counties, but was not widely raised in the upper Kansas. In drouth years it became more conspicuous than otherwise, because after most all other crops had failed it could be planted in mid-summer and with a favorable late summer and fall still make a crop. . . . Flax was tried in Geary county and recommended in 1862 for further experiment.—Professor James C. Malin in his recently released book *Winter Wheat in the Golden Belt of Kansas.*

Presidential Address

Kansas Academy of Science

1944

Famous Early American Observatories

HARVEY A. ZINSZER
Professor of Physics and Astronomy
Fort Hays Kansas State College, Hays.

"The heavens declare the glory of God; and the firmament sheweth his handywork."

About three years ago when I was relieved of the treasuryship of the Academy and it appeared that some day I might be honored with the presidency of this august body, my thoughts turned naturally to a consideration of a subject that I might best investigate and develop as a fitting token of esteem for the confidence bestowed upon me during this interim.

Strangely enough, of the various fields of physical science in which I have received training and which training, in turn, I have been endeavoring to impart to my students, the one of which I probably know the least, intrigued me the most. I refer to the field of astronomy.

Although other fields beckoned vainly trying to distract my attention and capture the center-stage of my thinking, astronomy, nevertheless, won out. But even here, there was a conflict as to whether I should speak on "Methods of Determining Stellar Distances", or on "America's Famous Observatories". Probably the fact that I had previously published concerning the former topic, is the reason for my choice of the latter. But to my dismay, after several years' work, I awoke to the fact, almost too late, that instead of a speech, I had compiled a book which accounts for the limitation imposed on my original title. Consequently, what follows will be merely a narration of the events which led to the foundation and later development of several of the earliest extant American observatories.

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The earliest commentary on this subject, a paper on "Astronomical Observatories in the United States", by Elias Loomis, was published in volume XIII (pp. 25-56, 1856) of Harper's *New Monthly Magazine.* The article describes the following observatories in their respective order of founding:

Yale College Observatory, (1830)
Williams College Observatory, (1836)
Hudson Observatory, Western Reserve College, (1837)
Philadelphia High School Observatory, (1838)
West Point Observatory, (1839)
National Observatory, Washington, (1842)
Georgetown College Observatory, (1843)
Cincinnati Observatory, University of Cincinnati, (1843)
Cambridge Observatory, Harvard College, (1843)
Sharon Observatory, Darby, Pennsylvania, (1845)
Tuscaloosa Observatory, Alabama University, (1843)
Rutherfurd Observatory, New York City, (no date)
Friends' Observatory, Philadelphia, (1846)
Amherst College Observatory, (1847)
Charleston Observatory, South Carolina, (1848)
Dartmouth College Observatory, (no date)
Shelby College Observatory, Kentucky, (1850)
Buffalo Observatory, (1851)
Campbell Observatory, New York City, (1852)
University of Michigan Observatory, (1853)
Cloverden Observatory, Cambridge, (no date)
Dudley Observatory, Albany, (1853)
Hamilton College Observatory, (1854)

Writing sixty-eight years later under the title of "Astronomical Observatories in the United States prior to 1848," W. C. Rufus, in volume XIX (1924) of the *Scientific Monthly,* submits the following list of observatories, also in chronological order:

John Winthrop, Harvard College, (1740)
Mason and Dixon, Philadelphia, (1763)
David Rittenhouse, Norriton, (1769)
James Madison, William and Mary College, (1789)
Ferdinand Rudolph Hassler, Survey of Coast, (1816)
William Cranch Bond, Dorchester, (1823)
Chapel Hill Observatory, North Carolina University, (1824)

Yale University Observatory, (1830)
Depot of Charts and Instruments, Washington, (1830)
Hopkins Observatory, Williams College, (1836)
Hudson Observatory, Western Reserve College, (1837)
Philadelphia High School Observatory, (1838)
West Point Observatory, (1839)
National Observatory, Washington, (1842)
Georgetown College Observatory, (1843)
Cincinnati University Observatory, (1843)
Harvard College Observatory, (1843)
University of Alabama Observatory, (1843)
Sharon Observatory, Darby, (no date)
Friends' Observatory, Philadelphia, (1846)
Amherst College Observatory, (1847)
Charleston Observatory, South Carolina, (no date)
Dartmouth College Observatory, (no date)

A comparison of the foregoing lists will reveal the fact that the observatories of the latter list antidates those of the former by about ninety years. This discrepancy is explained by the fact that several of the early observatories in Rufus' list were either privately owned or of a temporary nature. Then, too, Rufus had the advantage of a longer perspective.

A writer of our own time who probably was more conservative as to the significance of the term, "astronomical observatory," is Willis I. Milham who wrote on the subject of "Early American Observatories" in volume XLV (1937) of *Popular Astronomy*. His list which follows includes three private observatories, one of which later developed into the National Observatory at Washington, and eight institutional observatories:

David Rittenhouse Observatory, Norriton, (1769-1796)
William and Mary College Observatory, (1789)
Wm. Cranch Bond Observatory, Dorchester, (1823-1839)
Yale Observatory in Athenaeum Tower, (1830)
University of North Carolina Observatory, (1831-1838)
Depot of Charts and Instruments, Washington, (1833-1842)
Wesleyan University Observatory, Middletown, (1836)
Hopkins Observatory, Williams College, (1838)
Western Reserve Observatory, Hudson, (1838)
Miami University Observatory, Oxford, (1838-1840)
Harvard College Observatory at Dana House, (1839)

Astronomy During the Colonial Period

One of the earliest colonial observers to receive recognition abroad was Thomas Brattle of Boston. Josiah Quincy[1] attributes the following quotation to Baily in his supplement to the account of Flamsteed: "Mr. Thomas Brattle of Boston in New England, is the anonymous person alluded to by Newton, in his *Principia,* as having made such good observations of the comet of 1680." Several of Brattle's observations are preserved in the *Transactions of the Royal Society of London.* On June 12, 1694, he observed an eclipse of the sun at Cambridge, Massachusetts. The eclipse observations[2] were preceded and followed by taking altitudes of the sun "to rectify the watch."

Another colonial observer, whose work deserves more than passing interest, was Thomas Robie, who observed at Salem and at Cambridge. His earliest note[3] refers to an earthquake following which astronomical observations were made. His observation of the lunar eclipse of March 15, 1717, with a 24-foot telescope when compared with the observations of Cassini and De la Hire of Paris, made Cambridge 4h 55m 50s west of Paris.

Contemporary with the work of Brattle and of Robie in Boston, whose early observations excelled for their astronomical value rather than for geographical position, were the determinations of accurate latitude and longitude undertaken at other important centers for the benefit of geographers and surveyors. Examples of the latter[4] are the work of Sir William Keith in Philadelphia, and of Cadwallader Colden in New York.

On the matter of early boundary surveys and the Coast Survey, we quote first from Professor Rufus' paper: "Mason and Dixin arrived from England in 1763 to settle a boundary dispute between Pennsylvania and Maryland. Their first work in this country was to establish a surveying station and to determine its position with great care and accuracy. The building erected for this work just south of the city of Philadelphia, was called Mason and Dixon's Observatory. Extensive astronomical observations were made in 1763 and 1764, and the reduction of data has been styled the first astronomical computation in America."

Next, we quote from Milham's paper: "During the administration of Thomas Jefferson, Congress passed an act February 10,

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[1]Josiah Quincy: *History of Harvard University,* vol. I, p. 412, (1840)
[2]Benjamin Motte: *Philosophical Transactions Abridged,* vol. I, 264, 1721.
[3]*Philosophical Transactions Abridged,* vol. VII, 530, 1809.
[4]*Cadwallader Colden Papers,* vol. I, 159, 1918.

1807, authorizing the establishment of a Coast Survey. It was a bureau placed under the Secretary of the Treasury. The latter, with the approval of the President, issued a circular setting forth a project of a survey, inviting the attention of scientists to it, and requesting plans for carrying it into effect. In this project the proposed operations were to consist of: 1) the ascertainment, by a series of astronomical observations, of the true position of a few remarkable points on the coast; 2) a trigonometric survey of the coast between these points; and, 3) a nautical survey of the shoals and soundings of the coast, for which the trigonometric survey was to supply the basis."

Ferdinand Rudolph Hassler, a Swiss engineer of considerable experience and an instructor of mathematics at West Point, was appointed first superintendent of the Survey of the Coast. Owing to the lack of the necessary instruments and the interference raised by the War of 1812, field work was not begun until 1816, when a survey of the bay and harbor of New York was undertaken. In 1878, the bureau became the United States Coast and Geodetic Survey.

The greatest astronomical activity in America during the colonial period centered about the transit of Venus in 1769. However, years before, on April 27, 1740, Professor John Winthrop of Harvard College, observed a transit of Mercury with a 24-foot aerial telescope. Winthrop's expedition to Newfoundland, in 1761, to observe the transit of Venus was the first scientific expedition in this country provided by public expense.

At that time the American Philosophical Society was in existence and they voted to appoint a committee of thirteen to observe the 1769 transit of Venus. Some money was appropriated by the Society which being found insufficient was augmented by a grant from the Colonial Assembly. The committee was divided into three groups. One group under the leadership of Mr. Owen Biddle observed near the lighthouse at Cape Henlopen on Delaware Bay. Another group under the leadership of Dr. John Ewing observed in Philadelphia near the State House. The third and most important group of which David Rittenhouse was a member, observed at Norriton near Norristown. Each group erected a temporary observatory. The one in Philadelphia was said to have been an uncovered raised platform, while the observatory at Norriton is referred to as a log observatory. Considering the times, the committee was most fortunate in acquiring a quantity of excellent equipment. They

also had the good will and written direction of the Rev. Mr. Maskelyne, Astronomer Royal of England. The observations, published in the *Transactions of the American Philosophical Society,* volume VII, were so excellent that combined with the observations at Greenwich, a fairly accurate value of the solar parallax, and thus the distance of the sun, was determined.

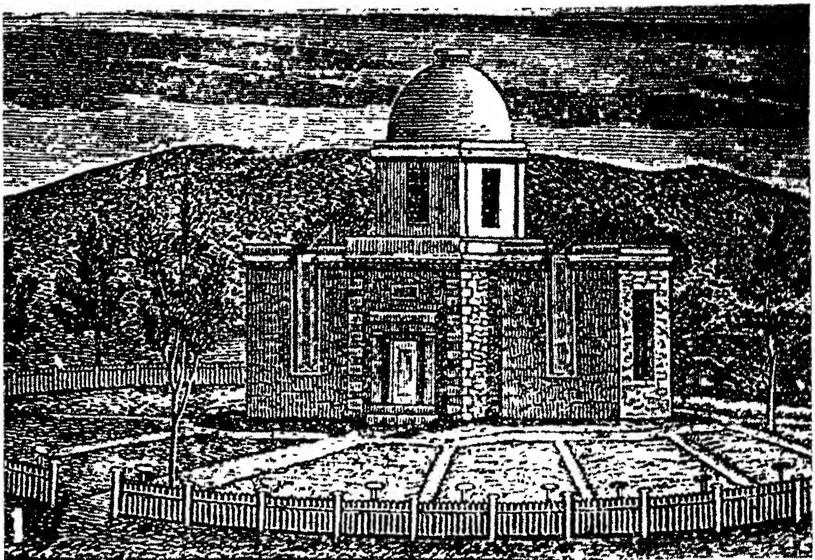
In 1770, Rittenhouse moved to Philadelphia and the Norriton Observatory was soon after dismantled. Rittenhouse located on the southeast corner of Seventh and Arch Streets. Diagonally opposite his residence, he erected a small but convenient octagonal brick observatory. In this observatory some of his instruments were installed and general observations were carried on, the results of which were published chiefly in the *Transactions of the American Philosophical Society.* Upon the death of Rittenhouse in 1796, this, the first American observatory, fell into disuse and was eventually dismantled.

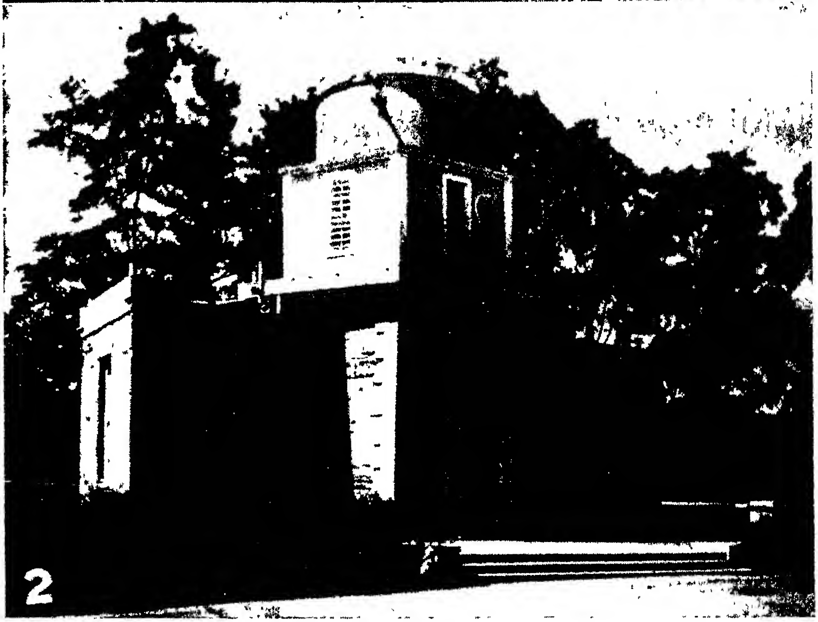
Evidence of the existence of a short-lived observatory contemporary with Rittenhouse is given in a communication[5] by David Rittenhouse of observations in 1789 by Dr. James Madison of William and Mary College to the American Philosophical Society: "Observations of a lunar eclipse Nov. 2d, 1789, and of the transit of Mercury over the sun's disc Nov. 5th, the same year, made at the University of William and Mary by the Rev'd. Dr. James Madison."

That his observatory had previously met with disaster is attested by the following quotation found in the same source as the former but read Feb. 4th, 1791: "As the observatory in which the transit instrument had been formerly placed was not, at this time, rebuilt, I was not enabled to attend to the going of the time-keeper, by means of such observations as I wished to have made. I, therefore, had recourse to correspondent double altitudes, taken with a sextant."

It is supposed that Bishop Madison—cousin of President James Madison—had excellent scientific equipment for the times. He was a man of strong scientific inclinations and was highly esteemed by the scientific men of his day. He was also a surveyor and thoroughly familiar with astronomical instruments. The latter quotation gives rise to the suspicion that the first observatory at William and Mary may have been destroyed about the time of the Yorktown campaign of 1781 when British soldiers and later French soldiers occupied some of the college buildings.

[5] *Transactions of the American Philosophical Society,* vol. III, 150, 1793.





The first permanent astronomical observatory in the United States, the Hopkins Observatory of Williams College. (Upper) From a woodcut in the Williams College Catalogue, 1838-39. (Lower) A photograph of the Hopkins Observatory at present. Both illustrations are reproduced through the courtesy of Professor Willis I. Milham, Williams College, Williamstown, Massachusetts.

America's Famous Observatories

Since the writer has compiled in chronological order historical sketches of thirty-six of America's most famous eighty odd observatories—and we use the term America in its larger sense—it seems fitting to enumerate, at this point, the names of the observatories in question. This paper, however, will be limited to the seven earliest of these observatories, still extant, whose fame has kept pace with the times. Herewith is the list of American observatories, together with the present director of each, and the date of founding:

America's Famous Observatories

Yale University Observatory, New Haven, (1830)
(Dr. Dirk Brouwer, Director)
U. S. Naval Observatory, Washington, (1830)
(Capt. J. F. Hellweg, Director)
Hopkins Observatory, Williams College, (1838)
(Dr. Willis I. Milham, Director)
Harvard College Observatory, Cambridge, (1839)
(Dr. Harlow Shapley, Director)
Georgetown College Observatory, Georgetown, (1843)
(Rev. Dr. Paul McNally, S. J., Director)
Cincinnati Observatory, University of Cincinnati, (1843)
(Dr. Paul Herget, Director)
Rutherfurd Observatory, Columbia University, (1848)
(Dr. Jan Schilt, Director)
Michigan University Observatory, Ann Arbor, (1855)
(Dr. Wm. C. Rufus, Director)
Allegheny Observatory, University of Pittsburgh, (1859)
(Dr. Nicholas E. Wagman, Director)
Dearborn Observatory, Northwestern University, (1862)
(Dr. Oliver Justin Lee, Director)
Princeton University Observatory, Princeton, (1866)
(Dr. Henry Norris Russell, Director)
Argentina National Observatory, Cordoba, (1870)
(Dr. Enrique Gaviola, Director)
Lick Observatory, University of California, Mt. Hamilton, (1875)
(Dr. W. H. Wright, Director)
National Astronomical Observatory of Mexico, Tacubaya, (1876)
(Dr. Joaquin Gallo, Director)
Goodsell Observatory, Carleton College, (1877)
(Dr. E. A. Fath, Director)

Washburn Observatory, University of Wisconsin, Madison, (1878)
(Dr. Joel Stebbins, Director)
LaPlata Astronomical Observatory, LaPlata, Argentina, (1882)
(Ingeniero Felix Aguilar, Director)
Leander McCormick Observatory, University of Virginia, (1883)
(Dr. Samuel Alfred Mitchell, Director)
Ladd Observatory, Brown University, Providence, (1891)
(Dr. Charles H. Smiley, Director)
University of Minnesota Observatory, Minneapolis (1892)
(Dr. W. J. Luyten, Director)
Lowell Observatory, Flagstaff, Arizona, (1894)
(Dr. V. M. Slipher, Director)
University of Illinois Observatory, Urbana, (1896)
(Dr. Robert H. Baker, Director)
Yerkes Observatory, Chicago University, Williams Bay, (1897)
(Dr. Otto Struve, Director)
Flower Observatory, University of Pennsylvania, (1897)
(Dr. Charles P. Oliver, Director)
Kirkwood Observatory, Indiana University, Bloomington, (1900)
(Dr. Frank K. Edmondson, Director)
Whitin Observatory, Wellesley College, Wellesley, (1900)
(Dr. John C. Duncan, Director)
Mt. Wilson Observatory, Carnegie Institution, Mt. Wilson, (1904)
(Dr. Walter S. Adams, Director)
Dominion Observatory, Ottawa, Canada, (1905)
(Dr. R. Meldrum Stewart, Dominion Astronomer)
Sproul Observatory, Swarthmore College, Swarthmore, (1906)
(Dr. Peter van de Kamp, Director)
Van Vleck Observatory, Wesleyan University, Middletown, (1914)
(Dr. Frederick Slocum, Director)
Stewart Observatory, University of Arizona, Tucson, (1916)
(Dr. E. F. Carpenter, Director)
Dominion Astrophysical Observatory, Victoria, B. C., (1917)
(Dr. J. A. Pearce, Director)
Perkins Observatory, Ohio Wesleyan University, Delaware, (1922)
(Dr. N. T. Bobrovnikoff, Director)
Astrophysical Observatory, California Institute of Technology, Mt. Palomar, (1929)
(Dr. J. A. Anderson, Executive Officer)
David Dunlap Observatory, University of Toronto, Toronto, (1932)
(Dr. R. K. Young, Director)

McDonald Observatory, University of Texas, Mt. Locke, (1933)
(Dr. Otto Struve, Director)
New National Astrophysical Observatory, Tonanzintla, Mexico, (1942)
(Dr. Luis Enrique Erro, Director)

YALE UNIVERSITY OBSERVATORY, NEW HAVEN, CONNECTICUT

In 1828, Mr. Sheldon Clark donated $1,200 to Yale College for the purchase of a telescope. Accordingly, a telescope larger than any in the country was purchased from Dolland of London. It had a focal length of ten feet and an aperture of five inches. Its maker declared it to be "perfect and such an instrument as he was pleased to send as a specimen of his powers."

It had a variety of eye-glasses and a spider-line micrometer of the best construction. It had an altitude and azimuth mounting without graduated circles. No building being provided, it was placed in Atheneaum Tower, one of the college buildings, where it was moved about on castors. The windows were low and no object more than 30° above the horizon could be observed. Under these circumstances, the telescope proved less serviceable than might otherwise have been anticipated. However, at the hands of Professor Denison Olmsted and Elias Loomis it was put to good use; and, in 1835, Halley's comet was observed weeks before news of its rediscovery in Europe reached America.

This phenomenon was the occasion of bringing prominently before the public the importance of large telescopes with all the accessories necessary for substantial astronomical observations. It not only gave new impulse to a plan for establishing a permanent observatory at Cambridge, but it also kindled anew the astronomical spirit of Philadelphia and excited a desire for instruments superior to those which were then possessed.

Other important discoveries were made with the Dolland telescope which appears to have been the only instrument in use at Yale for some time. Quoting Rufus, "Olmsted succeeded in creating great enthusiasm for astronomy, and drew about him a strong group of men who assisted in ushering in the new era of astronomy in America." The original Dolland telescope, the first instrument of the oldest existing American observatory, has been given a place of honor in the Franklin Institute in Philadelphia.

The present equipment of this observatory includes: a 15-inch

photographic refractor; a 10-inch visual refractor; a 6-inch heliometer; a zenith camera for latitude variation; a 9-inch equatorial visual refractor; a 8.5-inch equatorial visual refractor; a 6-inch wide-field camera. The principal work of this observatory comprises: photoelectric photometry; determination of stellar parallaxes and proper motions; and, occultations of the moon.

The present staff consists of twelve persons including Dr. Dirk Brouwer, the Director; E. W. Brown and H. L. Alden. Outstanding astronomers of the past, or now elsewhere, who have worked at the Yale Observatory are: Denison Olmsted; Elias Loomis; L. Twining; H. A. Newton; W. Elkin; and, Frank Schlesinger.

The United States Naval Observatory, Washington, D. C.

From 1809, when an amateur, William Lambert, presented his memorial to Congress recommending the establishment of a first meridian at the permanent seat of government, until 1830, all efforts to establish a national observatory had failed. Lambert determined the longitude of Washington and submitted his calculations to Congress with his memorial.

Prior to 1830, the navigational instruments and needs of ships were supplied by the purchase abroad through commercial agents, most of whom knew little about the requirements of these instruments. Upon receipt, instruments were frequently found entirely unsuited, or useless; charts and publications were in foreign languages; longitudes were not reckoned from a zero meridian; all of which required great effort and translation before becoming available for use in our naval service. When ships were decommissioned, their charts, navigational instruments, etc., were piled in a storehouse at the navy yard where they lay neglected until re-issue.

On December 6, 1830, the Secretary of the Navy upon recommendation of Lieut. L. N. Goldsborough, established the Depot of Charts and Instruments, and placed that officer in charge. Goldsborough was directed to collect from the commandants of the various navy yards the nautical instruments, books and charts not being used and to deposit them in the Depot. Among his other duties were: the determination of the errors of chronometers; the translation of all books, charts, pamphlets and other nautical information into English; and, the reduction of all charts to the meridian of Greenwich. The strange title, Depot of Charts and Instruments, was perhaps chosen to conceal its astronomical nature.

In 1833, Lieut. (later Captain) Charles Wilkes, a scientist of note, relieved Lieut. Goldsborough. Becoming incensed at the procrastination of Congress in providing suitable accommodations, Lieut. Wilkes built with private funds his own observatory, 16 feet square, located about 1000 feet north of the Capitol. Therein he mounted a 4-inch transit made by Troughton in 1815, and loaned to Wilkes by the Coast Survey. He also installed a 3½-inch portable telescope, a transit instrument, a sidereal clock, and other equipment. In 1835, a lithographic press was installed and chart production was begun.

The following year, Wilkes was sent to Europe to purchase scientific instruments to be used on his exploring expedition to the Pacific and the South Seas.

Meanwhile, in 1836, Lieut. James M. Gilliss was ordered to Washington and placed in charge of the Depot. Gilliss purchased the necessary equipment and instruments for the inauguration of a series of constant observations in astronomy, magnetism and meteorology. Included in this additional equipment were: a portable 4½-inch achromatic telescope, equatorially mounted; a variation transit; a comet seeker; a sidereal chronometer; and, later, a sidereal and a mean time clock.

When Captain Wilkes took charge of the exploring expedition in 1838, he recommended that a series of observations should be taken during his absence upon such celestial phenomena as might be available for the better determination of longitudes and their reference to some meridian at home. His recommendation was sanctioned and the observations were made in Washington by Lieut. Gilliss, and in Dorchester by William Cranch Bond, the latter continuing until 1839.

An Act of Congress, August 31, 1842, authorized the erection of a permanent Depot of Charts and Instruments for the Navy at a cost of $25,000. In the same year, Lieut. M. F. Maury, relieved Lieut. Gilliss, and the little observatory on Capitol Hill passed out of existence after ten years of intensive service. Here Lieut. Wilkes and Lieut. Gilliss had made literally thousands of excellent observations. The new Depot completed in 1844 soon became known as the United States Naval Observatory and was located at 23rd and "D" Streets, N. W., where the United States Naval Hospital now stands.

Wilkes was an astronomer, but Maury devoted his time to the

development of the hydrographic and meteorological work. He laid the foundation for the present internationally known system of hydrographic information and publications, and established his fame as an oceanographer. A year later, he began the systematic observations of the sun, moon, planets, and brighter stars, which have been continuous ever since.

In 1846, Maury published the first volume under the remarkable title *The First Volume of Astronomical Observations Ever Issued from an Institution Properly Entitled to the Name of Observatory On This Side of the Atlantic.* The work of the Naval Observatory was soon noted throughout the astronomical world. It was at the Naval Observatory, in 1847, that the planet Neptune, which had been discovered in 1846, was found to be the same star which had been seen twice before, in 1795, by the French astronomer Lalande.

Between 1854 and 1860 three minor planets were discovered by the Observatory. In 1873, Congress appropriated money for the purchase and installation of the 26-inch refracting telescope which at the time of its installation was the largest in the world. This instrument became famous in 1877, when Asaph Hall discovered the satellites of Mars with it.

The Naval Observatory was the first to use the telegraph in the determination of longitude between Baltimore and Washington, and later between Havana and stations in the United States. In September, 1903, the Navy began the installation of the first broadcasting apparatus in Navesink, New Jersey. In the spring of 1904, the broadcasting of correct time by radio signals on low power was inaugurated, followed in 1912 by broadcasting daily on high power from Arlington.

The Naval Observatory at present is divided into two major branches, the Nautical Branch and the Astronomical Branch. Its mission is: 1) to maintain continuous fundamental astronomical observations and calculations; 2) to prepare, publish and distribute the *American Ephemeris,* the *Nautical Almanac,* and other astronomical publications for maritime, commercial and scientific use; 3) to derive, maintain and disseminate the most accurate time for the national use; 4) to develop, procure and supply navigational instruments and equipment for vessels and aircraft of the Navy; and, 5) to contribute to the international advancement of navigation and astronomy.

The present location of the Observatory was selected in 1881; it covers 72 acres in the best residential section of Washington and comprises a total of 55 buildings. Its major telescopic equipment includes the following: a 40-inch Ritchey-Chretien aplanatic refractor; a 26-inch equatorial refractor by Clark; the mounting by Warner and Swasey; a 15-inch wide-angle photographic refractor by Warner and Swasey; a 12-inch visual equatorial refractor; a 10-inch equatorial refractor for photographing asteroids; a 9-inch transit circle; a 6-inch transit circle; and, a 5-inch photoheliograph.

The staff consists of twenty-four members including Captain J. F. Hellweg, the present Director; James Robertson, Director of the Nautical Almanac Office; Herbert R. Morgan, in charge of the 9-inch Transit; Harry E. Burton, in charge of Equatorials and the Astrographic Division; Chester B. Watts, in charge of the 6-inch Transit and the Time Vault; Paul Sollenberger, in charge of Time Service and the Latitude Variation Division; and, George W. Ritchey, Director of Photographic and Telescopic Research. Outstanding astronomers of the past who have worked at this observatory are: Asaph Hall; Joseph Winlock; Simon Newcomb; G. W. Hill; G. C. Comstock, and W. J. Hussey.

Hopkins Observatory, Williams College, Williamstown, Massachusetts

The first attempt to found a permanent astronomical observatory in this country was made in connection with Williams College in Massachusetts by Professor Albert Hopkins, founder and first director of Hopkins Observatory. Hopkins was born in Stockbridge, Massachusetts, July 14, 1807. He received his preparatory education at the Stockbridge Academy whence he entered the sophomore class at Williams College in 1824. After graduation in 1826, young Hopkins did surveying for a while and seriously considered entering the ministry. However, in 1828 he was invited to become a tutor at his Alma Mater, and in 1829 he was made professor which position he held until his death on May 24, 1872. He was a brother to Mark Hopkins who was president of Williams College from 1836 to 1872.

In June, 1834, Albert Hopkins visited Europe to study methods of scientific instruction and secure apparatus for this type of instruction. The sum of $4,000 was raised by subscription from among the alumni and patrons of the college for the purchase of philosophi-

cal and chemical apparatus for the use of the college. Hopkins sailed September 18, 1834, for Liverpool and returned the following May. He brought with him considerable apparatus, particularly astronomical equipment. It is likely that the older sidereal clock, the Troughton and Simms transit, and the Herschelian reflector of ten-foot focus were purchased at this time.

The next thing was to have a real astronomical observatory. In the fall of 1836, the quarrying of stone for the observatory was commenced; and, it is said that Professor Hopkins himself worked at stone-cutting with his own hands. In his diary for November 30, 1836, occurs this entry: "Went this afternoon to N. E. Mountain to quarry stone for my Observatory." He raised some of the money for the observatory and paid for part of it out of his own pocket. The records of the trustees show that the observatory cost $2,075 of which $1,200 was voted by the trustees, $400 was contributed by friends and the remainder was donated by Hopkins himself. The students also turned a helping hand in those days and occasionally turned out in a body to lend assistance in the construction of the observatory. In the spring of 1838, the observatory was practically completed and it was formally opened with an address by Professor Hopkins on June 12, 1838.

The Hopkins Observatory was built of native stone and consists of a central rotunda with two wings, the rotunda being surmounted by a revolving dome. The building was 48 feet long and the wings were nearly 14 feet wide. The vaulted ceiling of the rotunda was painted blue and on it gold stars were grouped to represent the constellations; the circles of the celestial sphere were also represented. The wings had openings on the walls north and south, also roof shutters. In the east wing, the Troughton and Simms transit instrument was mounted between two white marble piers. It had a focal length of 50 inches and an aperture of 3½ inches. The Molyneux sidereal clock was placed nearby. The transit instrument continued in this position until the building was moved in 1908. As far as is known nothing was ever mounted in the west wing. However, the Herschelian reflector was mounted under the revolving dome of the central rotunda.

In 1852, the 7-inch refractor which is now in use took the place of the Herschelian reflector. The former instrument was procured through the generosity of Amos Lawrence of Boston, and has an object glass by Clark but the mounting is by Phelps of Troy, New

York. Although one of Alvan Clark's first object glasses, the instrument was considered a very excellent one at that time. The sidereal clock bears across the dial, the name of Molyneux and Cope, London, which firm was in business from 1820 to 1840, producing nearly all the sidereal clocks which came to America during that period. It was a grandfather clock with a brass movement, a mercurial compensation pendulum and an anchor escapement. It is still running after a hundred years of service and giving good account of itself.

The first exact determination of the latitude of the Hopkins Observatory was made by Edward Williams Morley between 1860 and 1865. Morley graduated from Williams College in 1860 as Valedictorian of his class. He loved chemistry, the philosophy of Mark Hopkins and the astronomy of Albert Hopkins. In less than a year after his graduation, he was making latitude determinations. Apparently, the meridian circle was mounted temporarily in the open in the prime vertical about 100 feet south of the observatory. It was here under Albert Hopkins that he learned accuracy in observation. His results were communicated by Professor Hopkins and published in the *Proceedings of the American Academy of Arts and Sciences,* of January 10, 1865. Later, Morley became Professor of Natural History and Chemistry at Western Reserve College in Hudson, Ohio. He collaborated with Michelson in the well-known ether-drift experiment after Western Reserve University had moved to Cleveland.

In 1866, astronomy at Williams College benefited greatly by the generosity of the Field family largely through the influence of David Dudley Field of the class of 1825, and Professor Hopkins became the first Field Memorial Professor of Astronomy. The word astronomy appeared in the college catalogue for the first time in 1830-31 as a subject taught during the third term of the Junior year. The textbook was Enfield's *Natural Philosophy.* During the 44 years (1828-1872) that astronomical instruction was given by Professor Hopkins, five textbooks were used; Enfield's *Natural Philosophy* continued in use until 1831 when it was replaced by Olmsted's *Natural Philosophy.* In 1852, Robinson's *Astronomy* came into use and this was replaced by Lardner's *Astronomy* in 1858. In 1867, Loomis's *Astronomy* was mentioned for the first time as a textbook.

The question is sometimes raised as to whether Albert Hopkins was most famous as a teacher, a preacher or a man. He was deeply

religious in everything that he did. Over the north door of the observatory was placed this inscription: "Lift up your eyes on high and behold who hath created these." Over the south door was the inscription: "For thus saith the Lord, yet once, it is a little while, and I will shake the heavens, and the earth, and the sea, and the dry land." He is said to have been erect and dignified, with a frame that would have suited an athlete, and a head such as the Greek sculptors gave to their great orator; his eye was unmatched in brilliancy.

Following the demise of Albert Hopkins, there ensued an interim of four years during which the Field Memorial Professorship of Astronomy was vacant. During one of these years, astronomical instruction was given by Truman Henry Safford as Lecturer in Astronomy, and during two of them by Charles Augustus Young with the same title. Young later became Professor of Astronomy at Princeton University where he wrote the textbooks so well known to the older generation. In 1876, Truman Henry Safford was called to become the Field Memorial Professor of Astronomy which position he occupied until his death in 1901.

In 1882, the Fields again gave money to Williams College for astronomical purposes. A Repsold meridian circle of 4½ inch aperture was procured. In order to obtain a better horizon, a sheet-iron meridian house called the Field Memorial Observatory was constructed. Thus after 1882, Williams College possessed two observatories. Professor Stafford was much interested in meridian circle work and, consequently, used the Field Memorial Observatory to the neglect of the Hopkins Observatory. However, in 1908, when the layout of the campus was revised and new buildings were erected, the Hopkins Observatory was moved bodily a hundred feet to the south and turned slightly so as to square it with the campus rather than with the universe. At this time, the Hopkins Observatory was renovated and the clock, chronograph and broken transit by Wanschaff were moved from the Field Memorial Observatory to the Hopkins Observatory practically abandoning the former. In 1927, the College sold the site of the Field Memorial Observatory, and at that time the only remaining instrument in it, the Repsold meridian circle, was removed to the college museum leaving the Hopkins Observatory once more supreme.

Other outstanding astronomers of the past, in addition to those already enumerated who have worked at this observatory are Lewis Morris Rutherfurd and Robert G. Aitken.

HARVARD COLLEGE OBSERVATORY, HARVARD UNIVERSITY, CAMBRIDGE, MASSACHUSETTS

In October, 1839, the Harvard Corporation was informed that William Cranch Bond of Dorchester was engaged under an appointment and contract with the government of the United States, with well-adapted apparatus, in a series of observations on meteorology, magnetism, and moon-culminations, as well as upon all of the eclipses of the sun and moon, and Jupiter's satellites, in connection with those which should be made by the officers of the Expedition to the South Seas, commenced in 1838 for the determination of longiture and other scientific purposes.[6]

It occurred to President Quincy of Harvard, that if Bond would transfer his instruments to Harvard and pursue his observations there under the auspices of the university, it might facilitate the establishment of an observatory through the interest which his observations would arouse and by drawing the attention of citizens of Boston to the inadequacy of the means possessed by the university for difficult astronomical observations. Accordingly, steps were taken to raise $3,000 for the purpose of altering a dwelling house owned by the college and known as the Dana House, and adapting it for the use of Mr. Bond.

An inventory of Harvard's apparatus at this time included: an unreliable astronomical clock; a small transit, at one time loaned to Bowditch but returned because of little use; two reflecting telescopes of two and three feet focal length respectively; and, a quadrant. No more convenient place for using the instruments was available than an open field or a window which might accidentally open in the right direction. Bond brought to the Dana House a reflector of 30-inch focus, and an achromatic refractor of 40-inch focus, clocks, chronometers and magnetic apparatus. He was appointed director without salary, and yet the people did not respond.

The impulse toward awakening popular interest came from "the heavens itself." The unexpected appearance of the splendid comet of 1843 wrought the popular as well as the scientific mind into a state of excitement. It was a brilliant comet with a long train. The people of Boston naturally looked to the astronomers at Cambridge for information respecting its movements. The astronomers replied that they had no instruments. This announcement, together with the knowledge that good instruments were in existence in other

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[6] Josiah Quincy: *History of Harvard University*, vol. II, p 391, 1860.

parts of the United States, aroused the determination to supply the deficiency. Definite action was taken in March, 1843.

An informal meeting of a few individuals interested in the subject was held at the office of the American Insurance Company in Boston. The proceedings of this meeting were cordially seconded by the American Academy of Arts and Sciences; and a full meeting of merchants and other citizens of Boston was subsequently held at the hall of the Marine Society to consider the expediency of procuring a telescope of the first class for astronomical observations. At this meeting, the question was decided in the affirmative, and a subscription of twenty thousand dollars was recommended to defray the expenses. This amount was soon furnished.

David Sears of Boston gave five thousand dollars for the erection of an observatory, besides five hundred dollars toward the telescope. Another gentleman of Boston gave one thousand dollars for the same object; eight other gentlemen of Boston and its vicinity gave five hundred dollars each; there were eighteen subscribers of two hundred dollars each; and thirty of one hundred dollars each, besides many smaller sums. The American Academy of Arts and Sciences made a donation of three thousand dollars; the Society for the Diffusion of Useful Knowledge gave one thousand dollars; the American, the Merchants', and the National Insurance Companies and the Humane Society gave five hundred dollars each; two other companies gave three hundred dollars each; one gave two hundred and fifty, and another two hundred dollars.

The corporation of Harvard University purchased an excellent site of six and one-half acres, for the erection of an observatory. Elevated fifty feet above the university campus, it commanded a clear horizon in every direction, without obstruction from trees, houses, smoke and other causes. Upon this site, known as Summer House Hill, the Sears Tower was erected for the accommodation of the large telescope, with wings for the other instruments, and a residence for the director.

The central tower was 32 feet square, built of brick, resting on a granite foundation, and was surmounted by a circular dome 30 feet in diameter. Here was mounted the 15-inch telescope, which arrived in 1847, a product of the Munich firm of Merz and Mahler. It equalled, not only in size, but also in optical efficiency, the great refractor of the Russian National Observatory at Poulkovo. These

two "grand refractors" were the largest and most efficient in the world at the close of this period.

Merz and Mahler bound themselves by contract to make two object glasses of a clear aperture of fifteen inches, to be at least equal to that furnished for the noble instrument at Poulkovo. On being notified of the completion of these object-glasses, the agent of the University, Mr. Cranch of London, accompanied by the instrument maker, Mr. Simms, proceeded to Munich and after careful trial and examination made the required selection. The selected object-glass was received at Cambridge in December, 1846; the great tube and its equatorial mounting did not arrive until June, 1847. The object-glass of the telescope was fifteen inches in diameter, and had focal length of 22 feet 6 inches. Some of the eye-pieces were six inches long, making the entire length of the instrument 23 feet. The telescope had eighteen different powers, ranging from 103 to 2000. The movable portion of the telescope and machinery was estimated to weigh about three tons. It was, however, so well counterpoised in every position and the effects of friction were so far obviated by an ingenious arrangement of rollers and balance-weights, that the observer could direct the instrument at any part of the heavens by a slight pressure of the hand upon the ends of the balance rods. A sidereal motion was given to the telescope by clock-work, regulated by centrifugal balls, by which means a celestial object could be kept constantly in the field of view. The cost of the instrument was $19,842.

The optical character of this instrument gave entire satisfaction. The components of the star Gamma Coronae, which Struve with the Poulkovo refractor pronounced most difficult to separate, were seen in the Cambridge telescope distinct and round, and the dark space between them was clearly defined. The components of Alpha Andromedae, which are distant from each other less than half a second, were also separated with equal distinctness. The companion of Antares, estimated to be of the tenth magnitude, and which was discovered by Professor Mitchell with the Cincinnati refractor, was quite conspicuous with a power of 700. It was with this instrument that Mr. Bond discovered the eighth satellite of Saturn, two days before it was discovered by Mr. Lassell of Liverpool with his Newtonian reflector of 21-inch aperture. Bond also made satisfactory micrometric measurements of the satellite of Neptune, which is not known to have been done with any other instruments except Mr. Lassell's telescope and the Poulkovo refractor.

The transit circle by Simms of London was erected in the east wing of the Sears Tower. It had two circles, each of four feet diameter, graduated on silver to five minutes, and read to single seconds by means of eight microscopes cemeted to the granite piers, four to each circle. The object-glass by Merz and Mahler had an aperture of four and one-eighth inches, and a focal length of 65 inches. It had two different modes of illumination, one through the axis as usual, the other at the eye-piece showing bright wires on a dark field. Attached to the eye-piece were two micrometers for measuring both altitude and azimuth. There was also belonging to the observatory a fine comet-seeker, by Merz and Mahler, having an aperture of 4½ inches. The wing on the north side of the tower was designed to receive a transit in the prime vertical.

Today, the Harvard College Observatory maintains four observing stations: the Boyden Station near Bloemfontein, South Africa; the Oak Ridge Station in Harvard, Massachusetts; the Solar Station at Climax, Colorado; and the original observatory in Cambridge, Massachusetts. The Boyden Station has existed in the southern hemisphere since 1890, first at Arequipa, Peru, and since 1927 near Bloemfontein, Orange Free State. At Cambridge, increasing sky light from the neighboring cities made observing inefficient, hence in 1932 the Oak Ridge Station was established twenty-seven miles northwest of the city.

The equipment at the southern and northern stations is comparable, ranging from the sixty-inch reflectors through the large refractors to the short-focus patrol cameras. When all stations simultaneously enjoy clear skies, twenty-one telescopic cameras indelibly record the heavens. During the past year nineteen thousand photographic exposures were taken and shipped to Cambridge for detailed examination, cataloguing and filing. Nine thousand plates came from the Boyden Station, nearly seven thousand from Oak Ridge, and over three thousand from the cameras remaining at Cambridge. Such systematic photography of the sky began in 1885, and the number of accumulated plates is rapidly approaching a half-million.

The recently established Solar Station located at Climax, Colorado, at an elevation of 11,500 feet, is being equipped with a Lyot coronagraph. Final adjustments of the instrument are nearly completed and it is hoped that routine observations of the solar chromosphere and inner corona will soon begin. This instrument is the

third of this type in the world and the first to be installed in the western hemisphere.

Numerous other instrumental developments are now in advanced stages of construction. The largest of these is the transformation of one of the sixty-inch reflectors into a sixty-inch Schmidt-type camera. Although this transformation was originally planned for the telescope at the Boyden Station, world political conditions may force a revision of the plans. When completed, this instrument will be extremely powerful for the study of faint galaxies and stars over appreciable areas of the sky. A twenty-four inch Schmidt camera for the Oak Ridge Station was recently completed and is now in operation.

In addition to the photographic cameras at Oak Ridge, a twenty-inch reflector is fitted for photoelectric photometry and the sixty-one inch reflector has been used considerably for photoelectric and thermoelectric investigations. A slit spectrograph containing a 15,000-line grating by R. W. Wood and a F/1 Schmidt camera has recently been installed on the large reflector.

"This wealth of instrumental equipment is utilized in a variety of interlocking investigations upon the nature and distribution of celestial bodies throughout the Milky Way and extragalactic space. Surveys of spatial distribution of galaxies to the 13th, 15th and 18th magnitudes are among the largest of current studies. . . . Up to the present, more than half completed, they have revealed half a million new galaxies; when completed the total will be not less than eight hundred thousand. . . . These data reveal inhomogeneities in the distribution of galaxies—great clusters of supergalaxies; also a widespread metagalactic density gradient across the southern galactic cap."

An important phase of the Harvard Observatory's program is the analysis, both observational and theoretical, of astronomical spectra. One co-operative attack is upon the absorption and re-emission of radiation within planetary nebulae and similar "dilute" atmospheres. This analysis is not unrelated to the problem of the composition and physical state of the solar corona, which remains a mystery. The calculation of the spectral-line intensities from a knowledge of the structure of various atoms, especially helium, is nearing completion and will first be applied to the interpretation of very hot stars.

The spectral classes of stars are fundamental in studies of the

celestial population, both as individuals and *en masse*. Already four hundred thousand stars have been classified at Harvard on a uniform system. Recently a considerable portion of this work has been in co-operation with other observatories which were publishing catalogues and wished to add spectral types to their other information about the stars included.

The staff at Harvard College Observatory comprises 44 members including: Dr. Harlow Shapley, Director, specializing in studies of the Metagalaxy; William H. Pickering, specializing in studies of Mars; Dr. Donald Menzel, specializing in spectroscopy; Dr. Bert J. Bok, specializing in stellar statistics and interstellar absorption; Cecelia Payne Gaposchkin, specializing in stellar photometry and spectroscopy; and, Ernst J. Opik, specializing in meteoric statistics.

Outstanding astronomers of the past, or now elsewhere, who have worked at this observatory: George Bond; Edward C. Pickering; Solon I. Bailey; Edward S. King; Asaph Hall; S. P. Langley; William J. Luyten, now Director of Minnesota Observatory; Harry H. Plaskett, now Savilian Professor of Astronomy at Oxford; and Annie J. Cannon.

Georgetown College Observatory, Georgetown University, Georgetown, District of Columbia

Volume I of the *Annals of the Astronomical Observatory* of Georgetown, D. C., published in 1852, begins with these words: "During the winter of 1841, the Rev. Thomas Meredith Jenkins, one of our members, offered a donation to the College for the purpose of building and furnishing an Observatory and the Rev. Charles Henry Stonestreet offered to supply an equatorial. In 1842, the donations were accepted and the building of the House determined upon. In the summer of 1843, the ground plan for the excavation of the cellar was laid off. . . ." That was the beginning of the Georgetown College Observatory, whose hundredth birthday was recently observed. The Rev. Thomas Meredith Jenkins, mentioned above, was at that time a Scholastic. He was ordained in 1846, and died of yellow fever at Rio de Janeiro on April 11, 1850. His body was later brought to Georgetown and buried there on July 27, 1853.

The first director of the Observatory was Fr. James Curley, who had started teaching at Georgetown in September, 1831. He continued to teach there until July, 1879, a period of 48 years. He was director of the Observatory from its beginning until 1886.

Work was commenced on the observatory building July 8, 1843. The main part of the building was 30 feet square and two stories high, surmounted by a dome 20 feet in diameter. Up through the center of the building was built a pier to support the equatorial telescope, a 4.8-inch refractor by Simms of London, delivered in 1849. Attached to the main building, east and west, were one-story rooms, 15 by 30 feet. The one on the west side housed a transit instrument of 4½-inch aperture made by Ertel and Son of Munich; and a sidereal clock by Molyneux of London. The east room contained a meridian circle made by Troughton and Simms of London in 1845. Here also was a Molyneux sidereal clock presented "by the liberality of T. Robert Jenkins, Esq., of Baltimore."

The first known observations at the Observatory were those of the brilliant comet of 1843, made by Father Curley over the better part of a month.

The first problem confronting a new observatory is to know where it is, that is, its longitude and latitude. This Father Curley set out to do, without such modern aids as radio time-signals. In 1850, he sent to the Royal Astronomical Society his results, as well as the latitude and longitude of the Naval Observatory, the White House, the Washington Monument, the Capitol and other places as determined from Georgetown. The longitude checked exactly with that determined by Fr. Phillips during the International Longitude Survey of 1926, made with the help of radio.

In 1848, Frs. Francis de Vico, Benedict Sestini and Angelo Secchi, and a Scholastic by the name of Rosa, arrived after being expelled from the Roman College Observatory. Fr. de Vico, who had been director of the Roman College Observatory, was immediately given the same post at Georgetown. He decided that before any work could be done, the observatory should be greatly enlarged. He soon started back to Europe to purchase instruments. In Liverpool, he caught typhus fever, and, although he recovered from the attack, he was so greatly weakened that he died soon afterwards at London. Fr. Sestini stayed here, and during the summer of 1849 began his sunspot drawings and made a series of observations on star colors, using the objective brought from Rome by Fr. de Vico. This lens is still at Georgetown. The work on sunspots was published later by the Smithsonian Institution.

The observatory was originally built as a students' observatory, but it gradually lost that character, although, as late as 1876. Fr.

Curley, then 80 years of age, occasionally brought students to look through the telescope. Occasionally a Jesuit, later to become well-known, came to study at the Observatory. In the summer of 1873, Mr. William F. Rigge of the Missouri Province came from Woodstock to study. He was later to become director of the Creighton University Observatory, and to become well known for his books on *The Harmonic Motion Machine* and on the *Prediction of Eclipses and Occultation,* and for numerous articles in astronomical journals. He was assistant at the Georgetown College Observatory in 1895-6. Another famous name is that of Fr. Jose Algue, who came from Barcelona in 1891 to learn theoretical and practical astronomy, although his greatest work was to be in meteorology. He later became director of the Manila Observatory and was famous for his invention of the barocyclonometer for the prediction of typhoons.

Fr. Curley died on July 24, 1889, at the age of 93 years. He had been succeeded as director three years previously by Fr. Samuel H. Frisbee. A year later, in 1887, Mr. James F. Dawson became acting director.

In December, 1888, a new phase in the life of the Observatory began with the arrival of Fr. John C. Hagen from Prarie du Chien as the new director. He put the observatory in order and purchased the 12-inch telescope from Saegmuller of Washington, though the lens was made by Clark of Cambridge, Massachusetts. This instrument was mounted in the dome to replace the 5-inch, which was removed to a small house southwest of the main building.

Fr. Hagen's principal work was the *Atlas Stellarum Variabilium,* of which three series were published while he was at Georgetown, and three more were published at Rome, based on his observations at Georgetown. While at Georgetown, he also published three volumes of the *Synopsis der Hoeheren Mathematik.*

In June, 1890, Fr. George A. Fargis was appointed assistant at the Observatory. In the following year, he published an account of the new photochronograph. He stayed at the Observatory until 1895, when he was replaced by Fr. Rigge.

In 1906, Fr. Hagen left for Rome to take up the position of director of the Vatican Observatory, and held that post until his death in 1930. The Georgetown Observatory had entered upon a long period of inactivity. Fr. John T. Hedrick was director from 1906 to 1914, being succeeded by Fr. Peter Archer, who spent much time putting the observatory into working condition again, though

little observation was done. He was succeeded in 1923 by Fr. John L. Gipprich, professor of physics at the College.

In 1925, Fr. Edward C. Phillips was appointed director. The same year Fr. Paul A. McNally was named assistant director, and the following year he went to the University of California for graduate work in astronomy. Fr. Phillips took part in the International Longitude Survey, as noted earlier in this paper, and began a program of observation of occultations and of visual observation of variable stars. However, in 1928, Fr. Phillips was appointed Provincial of the Maryland-New York Province, and Fr. McNally was recalled from California to take charge. Fr. McNally instituted a number of improvements, including electrification of the large dome, the mounting of two cameras on the 5-inch telescope and its electrification, and the purchase of a measuring engine. The work on occultations was continued, with the result that up to the end of 1939, occultations to the number of 748 have been observed and published. In addition to this, a program of photographic observation of variable stars was begun with the new cameras.

In the summer of 1932, the first Georgetown University Eclipse Expedition traveled to Fryeburg, Maine, to observe the total eclipse of the sun on August 31. On the day of the eclipse, the party consisted of Father McNally, director of the expedition, Fathers Barry, O'Connell (now director of the Riverview College Observatory, Sydney, Australia), Sohon, Thomas Smith, Merrick, Quigley and Kolkmeyer, and Mr. Miller. Fr. John Stein, director of the Vatican Observatory, was also present as observer. The expedition was eminently successful. The pictures were pronounced the best taken of that eclipse, and among the best taken of any eclipse. Enlargements are on permanent display at the National Geographic Society, the Fels Planetarium in Philadelphia, the Adler Planetarium in Chicago and other places. A silver certificate of merit was awarded Father McNally by the photographic committee of the Century of Progress Exposition at Chicago. This expedition brought much publicity to Georgetown, as an account of it was published in the *National Geographic Magazine*, with a circulation of 1,400,000.

In 1936, a joint expedition with the National Geographic Society journeyed to Kustanai, Siberia, to observe the eclipse of July 19th. Fr. McNally directed the party which included Frs. Thomas Smith and Kolkmeyer. Unfortunately clouds prevented any observations.

The following year, Fr. McNally went to Canton Island in the

South Pacific as a member of a joint expedition sponsored by the National Geographic Society and the United States Naval Observatory. This was the largest eclipse expedition ever to leave the United States, and was also distinguished for the fifteen broadcasts from the scene over the National Broadcasting Company, the first time such broadcasts were ever made. Success crowned the efforts of this expedition also, and more publicity was obtained through the medium of the *National Geographic Magazine* with its immense circulation.

At the time this information was received from the Georgetown Observatory, its indefatigable director was planning on making his fourth eclipse expedition, this time with the National Geographic Society to Patos, in the State of Parahyba in eastern Brazil. This was supposed to have been the most elaborate eclipse expedition ever attempted, since all of the observations were to have been automatically controlld by electricity. Needless to say, the exigencies of World War II prevented its occurrence.

Cincinnati Observatory, University of Cincinnati, Cincinnati, Ohio

The Cincinnati Observatory owes its existence to the labors of Professor Ormsby MacKnight Mitchel, who, as a graduate of West Point was a classmate of Robert E. Lee and of Joseph E. Johnson. In the winter of 1841-42, after several years of checkered career, Mitchel accepted an invitation to deliver a course of lectures on astronomical subjects before the Society of Useful Knowledge. His lectures were received with great enthusiasm, and at their close he announced his determination to secure for the people of Cincinnati an astronomical observatory equal in instrumental equipment with the best in the world.

Mitchel organized the Cincinnati Astronomical Society, the first popular organization of its kind and with a heterogeneous membership. He proposed to raise $7,500 in shares of $25 each, every subscriber to be a member and entitled to the privileges of the Observatory. Eleven thousand dollars were subscribed and a site for the building was given by Nicholas Longworth, Esq. It consisted of four acres of ground on one of the highest hills, subsequently named Mount Adams, and was located on the eastern side of the town.

In June, 1842, Professor Mitchel visited Europe to purchase a

telescope. At Munich, he found an object-glass of 12 inches aperture made by Merz and Mahler, which had been tested by Dr. Lamont and pronounced one of the best ever manufactured. This object-glass was subsequently ordered to be mounted, the purchase price for the completed instrument being $9,437.

On November 9, 1843, the corner-stone of the Observatory was laid by the venerable John Quincy Adams, then 77 years of age. His eloquent oration on that occasion was one of the last public acts of his noble life. One may recall his rebuff by Congress nearly 20 years before when urging a national observatory. Here was his opportunity. He lamented the apathy of the nation toward the claims of astronomical science and congratulated the citizens of Cincinnati on the fact that their generosity and enthusiasm had at length wiped the reproach from the fair name of their beloved country.

This "temple of astronomical science," as it was called, was 80 feet long and 30 feet broad. Its front presented a basement and two stories, while in the center the building rose three stories in height. The pier was built of stone, and was grouted from its foundation on the rock to the top. The equatorial room was 25 feet square, and was surmounted by a roof so arranged that it could be entirely removed during the time of observation.

The object-glass of the telescope which arrived in Cincinnati in February, 1845, had an aperture of 12 inches, and a focal length of 17 feet. The hour-circle was 16 inches in diameter, and was read by two verniers to two seconds. The declination circle was 26 inches in diameter and was divided on silver to five minutes, reading by verniers to four seconds. The instrument had five common eye-pieces and nine micrometrical with powers varying from 100 to 1400. It was furnished with clockwork by which a star was kept steadily in the field of view of the telescope.

During the first year, five evenings out of the week were given up to the seven hundred odd members of the Cincinnati Astronomical Society who had underwritten this venture and, in subsequent years, half of the evenings. Such use was doubtless one reason why less of a strictly scientific character was accomplished than might have been anticipated with so fine an instrument. All the money that could be raised by public subscription having been expended upon the telescope and the building, it was found impossible to make any provision for the endowment of the institution. Professor Mitchel, therefore, agreed to act as director for ten years

without salary, relying upon the income he received from the college as professor for the support of his family. But scarcely had the observatory been finished, when the college building burned down and his salary as professor ceased. Unable to live on his salary as director, he again took to the lecture field and at one time became a railroad engineer.

But it should not be inferred that Mitchel did *nothing* with the telescope that had cost him such effort to secure. From his lecture tours during the winter he would return with means to carry on his work at the observatory until the following autumn. He devoted much of his time to the re-measurement of Struve's double stars south of the equator. Some stars previously marked as oblong were separated; others marked double were found to be triple; while his observations combined with Struve's demonstrated the fact that many of the stars were physical binaries.

In 1846, Mitchel commenced the publication of the *Sidereal Messenger,* the first magazine devoted to a popular exposition of astronomy. But the time had not yet come when such a publication could be made self-supporting, and it was discontinued at the close of 1848. Mitchel was one of the first to apply the principles now embodied in the chronograph to the recording of time, though he laid no claims to having originated the idea.

In 1860, Mitchel was appointed director of the Dudley Observatory at Albany; Henry Twitchell, who had for several years been his assistant, remaining in charge at Cincinnati. The breaking out of the Civil War in the following year closed forever Mitchel's astronomical career, for Ormsby MacKnight Mitchel was recalled to the United States Army as Brigadier General at the beginning of the war and died of yellow fever at Beaufort, S. C., October 30, 1862.

During the troublous times that followed, no attempt was made to carry on astronomical work at Cincinnati. Mr. Twitchell having resigned in 1861, the Observatory remained virtually idle until the appointment, in 1868, of Cleveland Abbe, of the National Observatory at Washington as director.

Probably the most important work which Professor Abbe accomplished during his connection with the Observatory was the establishment of a system of daily weather reports and storm predictions. Having secured the co-operation of observers stationed at various points throughout the nation, he began to issue the *Weather Bulletin* on September 1, 1869.

Although the Observatory only maintained this service for a few months—it passing then temporarily into the hands of the Western Union Company—still, the experiment had the effect of arousing popular interest in the subject, and led to the speedy establishment by the Federal Government of the Weather Bureau. Upon the establishment of the National Signal Service, it was but natural that Professor Abbe's ability and experience in meteorological work should be in demand at Washington. He resigned the directorship of the Observatory in 1870, to accept the directorship of meteorology in the United States Weather Bureau.

The property on Mount Adams donated by the late Nicholas Longworth having become unsuitable for that purpose, the heirs joined with the Astronomical Society in an agreement to give and convey the ground to the city, upon the specific trust that it should be leased or sold and the proceeds applied toward endowing the School of Drawing and Design, then established in connection with the University the city agreeing, as a condition of the gift, to sustain an observatory also to be connected with the University.

To enable the city to comply with the latter agreement, John Kilgour agreed to give four acres of land as the site for the new observatory, and also the sum of ten thousand dollars for building and equipping it. The Astronomical Society also gave to the city, for the same object, the equatorial and other instruments, with all the apparatus and astronomical records and books belonging to the observatory.

The site so generously donated by Mr. Kilgour was located on the summit of what is known as Mount Lookout, approximately three and one-half miles east and two miles north of the old observatory. In 1875, Ormond Stone, of the National Observatory at Washington, was appointed director. Work on the southern double stars was at once taken up, and vigorously prosecuted; four catalogues containing measures of over two thousand doubles being issued during Professor Stone's administration. Professor Stone was appointed chief of one of the Government parties sent out to observe the total eclipse of 1878. He resigned in 1882 to accept the directorship of the Leander McCormick Observatory of the University of Virginia. Mr. Herbert C. Wilson who was assistant for some years, remained in charge until the appointment, in 1884, of Jermain G. Porter, previously connected with the United States Coast and Geodetic Survey.

The major telescopic equipment of the Cincinnati Observatory consists of: an 11-inch equatorial refractor, originally by Merz and Mahler but re-figured by Alvin Clark in 1876; a 5-inch meridian circle by Fauth of Washington; a 3-inch portable transit instrument by Buff and Berger of Boston; a 4-inch portable refractor by Clark; a sidereal clock by Molyneux of London; a mean-time clock by Ritchie and Son of Edinburgh; a sidereal chronometer and a chronograph by Bond and Son of Boston; and a magnetic theodolite by Gambey. The principal work comprises the cataloguing of double stars; observations on comets; micrometric measurements of nebulae; variations of latitude and determination of orbits. Dr. Elliott Smith is the present director.

Rutherfurd Observatory, Columbia University, New York City

With the exception of a brief reference to the Columbia College Observatory by Loomis, little material on the early history of this observatory is readily available. Were it not for this brief reference, a quotation of which follows shortly, one would be inclined to set 1883 as the date of the founding of Columbia University's Observatory, when in December of that year, Lewis Morris Rutherfurd made an unconditional gift of his entire astronomical equipment to the Columbia College Observatory.

Writing in 1856, Loomis relates: "Connected with this observatory (Rutherfurd's) is a small building, containing a transit instrument by Simms, belonging to Columbia College. The telescope has an aperture of nearly three inches, and a local length of four feet. It is mounted upon two stone columns resting upon a solid foundation of sandstone. An opening in the roof affords a view of about 160° of the meridian. In a small wing of this building is a stone column upon which is placed an altitude and azimuth instrument by Simms, belonging to Columbia College. The horizontal and vertical circles are each 15 inches in diameter, graduated to five minutes, and reading by two microscopes to one second of arc. The telescope has an aperture of two inches and a focal length of 24 inches. During the summer of 1848, this observatory was employed by the Coast Survey as a station for determining the difference of longitude between Cambridge and New York by means of the electric telegraph."

Lewis Morris Rutherfurd descendant of Lewis Morris, a signer

of the Declaration of Independence, was born at Morrisania, New York, on November 25, 1816. At the age of fifteen, he entered the sophomore class at Williams College where he showed his love for investigation, for which he was appointed assistant to the professor of chemistry and physics. His duties included the preparation of lecture demonstrations. After graduation, he studied law being admitted to the bar in 1837. In the early part of his professional career, he married Margaret Stuyvesant Chanler, niece of Peter G. Stuyvesant. His wife's fortune added to his own made it agreeable and possible for him, in 1849, to abandon law and thereafter devote his leisure to science, principally astronomical photography and spectrum analysis.

In 1849 he travelled in Europe and studied with the Italian optician Amici. He remained abroad some time traveling and studying. On his return to New York City, he erected in his garden, at Second Avenue and Eleventh Street, a small but excellent observatory. The building was arranged to contain a transit instrument, clock and equatorial telescope. It was a very modest building but destined to be the witness of great deeds.

Nearby, in the fine dwelling house, were a commodious study and a work-ship fitted with turning lathes and tools of all kinds necessary for his work. The splendid work of Bunsen and Kirchhoff was then attracting great attention, and Mr. Rutherfurd devoted most of his time to spectroscopic investigations. In January, 1863, he published in Silliman's *American Journal of Science,* vol. XXXV, a paper on the spectra of stars, moon, and planets. In this paper, he gave diagrams of the lines and a description of the instruments employed. This paper was the first published work on star spectra.

In the course of his observations upon the stellar spectra, he discovered the use of the star spectroscope to show the exact state of the color correction in an object-glass, particularly for the rays used in photography. Patiently and skillfully he followed up this trail, and in 1864, after many experiments in other directions, but always aiming at the same end he succeeded in devising and constructing, with the aid of Mr. Fitz, an object-glass 11¼ inches in diameter and about 15 feet focal length. This lens was corrected for photography alone and was useless for vision. A very brief account of this glass and of the prior experiments was published by Mr. Rutherfurd in the *American Journal of Science* for May, 1865.

In 1868, he finished his 13-inch object-glass. The 11¼ inch

was taken by Dr. Gould in 1870 to South America. The new glass ordinarily had a focal length of fifteen feet, but when connected with a third lens of flint glass, which made the proper correction for photography, the focal length was shortened to 13 feet. This correcting lens could be fixed outside of the ordinary seeing glass, in a few minutes, by three set screws. All the photographs taken after 1868 were made with this new instrument.

During 1870, Mr. Rutherfurd constructed a ruling engine described and figured in *Appleton's Cyclopaedia* under "spectrum." With this beautiful apparatus he produced superb interference gratings on glass and on speculum metal. Some of the ruled plates had 17,000 lines to the inch; they were superior to all others down to the time when Professor Rowland perfected his machine.

Mr. Rutherfurd took a leading part in assisting President Barnard to form, with the aid of Professors Peck and Trowbridge, a Department of Geodesy and Practical Astronomy at Columbia College in 1881. When the trustees built the fine library building, an observatory was placed on the top of the edifice, and accommodations were prepared for equatorial, transit and other instruments.

In December, 1883, Mr. Rutherfurd made an unconditional gift to the Columbia College Observatory of his 13-inch telescope with its photographic correcting lens, his transit instrument, Dent clock, measuring micrometer, barometer and other apparatus. He was aware of the importance to science of a complete reduction of his measures on the star plates. So on November 13th, 1890, Mr. Rutherfurd gave all his negatives of the sun, moon and star groups to Columbia University. With these negatives came twenty folio volumes of about two hundred pages each containing the measures of many of the plates. This valuable contribution has been placed in a fire proof vault at the College Observatory.

The latest Rutherfurd Observatory is located on the roof of the Pupin Physics Laboratories at Columbia University, the offices and classrooms occupying the fourteenth floor directly below. Naturally, when the Pupin Laboratories were built, the new observatory was named for Lewis Morris Rutherfurd who had built the first photographic telescope and who had donated his entire astronomical equipment to the University. In 1935, the 13-inch photographic telescope was removed from the New York Museum of Science and Industry where it had reposed for a number of years, and brought back to Columbia and attached rigidly to the 12½-inch Clark visual refrac-

tor. The *Clark* telescope is thus used for guiding while taking plates with the Rutherfurd.

During the last few years Rutherfurd's plates of the Pleiades and of Praesepe have been duplicated with the same telescope and under as nearly as possible the same conditions. Of course, Rutherfurd used wet plates which were of different color sensitivity than ordinary photographic plates in use today. However, the Eastman Kodak Company succeeded in approximating the color sensitivity and other characteristics of the wet plates for this program. The relative positions of the cluster stars on corresponding pairs of plates were measured, and accurate values of the internal proper motions were obtained from which an upper limit to the mass of the cluster was derived. Very accurate positional work is also possible with the Rutherfurd telescope when uncorrected for photographic work and operating at a focal length of fifteen feet. At present, it is being used in connection with a study of the systematic errors which occur in parallax work.

Another program of the Observatory is the measurement of photographic magnitudes. The plates for this work are taken at Yale Observatory with the 3-inch Ross lens of 21-inch focal length. They are measured in a Schilt microphotometer and the magnitudes are obtained by comparison with standard stars in the region of the North Pole, which is photographed on each plate as well as the region to be measured. When the present program is completed photographic magnitudes of over 75,000 stars in the northern hemisphere, mostly brighter than the tenth magnitude, will have been taken. This material, a third of which has already been published, is useful in many problems. For instance, a comparison of the photographic and visual magnitudes of a star gives its color. It will be possible, therefore, to derive some interesting information about the reddening of starlight due to absorption by material in inter-stellar space. For many of the stars, there is additional observational material available, such as proper motion and spectral type, which is being utilized in a statistical study of the magnitudes in connection with this additional data.

The Astronomical Hollerith-Computing Bureau was established at Columbia University in 1937. It is operated under the joint direction of the American Astronomical Society, the International Business Machines Corporation and Columbia University; its purpose is to carry out astronomical calculations which would be too lengthy

or laborious to undertake by hand. The data to be used are punched on tabulating cards and the Hollerith machine performs various arithmetical operations by means of electrical contacts made through the holes in the cards.

One problem on which the Bureau is working is the computation of accurate orbits for sixteen asteroids. These are to be used in a problem suggested by Simon Newcomb many years ago. Hence on a photographic plate, the asteroid can be used as a reference point for the stars, and the star positions determined with respect to known positions of the asteroids. In this way, it is planned to determine the systematic errors in previous catalogues of star positions.

The bureau has also undertaken the verification of the "lunar theory" of the late Professor E. W. Brown of Yale. Professor Brown devoted the greater part of his life to the accurate determination of the motion of the moon. Much of his work was done by hand or by the early calculating machines, and the labor involved was tremendous. The work has been verified and extended on the Hollerith machines in about three years. As an example of the magnitude of the operations involved, it was necessary to multiply together series of five hundred terms each, while the numbers themselves were of ten digits. At the present time, the card files of the Bureau contain about two million cards of astronomical data and useful tables.

In addition to Dr. Jan Schilt, the present director, some of the outstanding astronomers of the past, or now elsewhere, who have worked at this observatory are: J. A. Gould; E. W. Brown; John K. Rees; Harold Jacoby; Herman S. Davis; Wallace J. Eckert; and Martin Schwartzschild.

An Ecological Study of Four Species of Sumac in Relation to Development and Growth on Eroded Soil

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The purpose of this investigation was to test and prove the hillculture crop value of various Iowa sumacs as erosion control and economic tannin-producing plants. The four species of sumac chosen for observation and possible investigation were *Rhus aromatica* Ait., fragrant or aromatic sumac; *Rhus copallina* L., black or dwarf sumac; *Rhus glabra* L., white or smooth sumac and *Rhus typhina* Torn., staghorn sumac. Experiments with these shrubs were begun in 1938 at the time that plantations of grapes, plums, nut trees, post trees and other woody plants of economic value were established in this area on eroded hillsides. The field work of these studies was done at the Hillculture Experimental Farm at Floris, Iowa.

It was apparent that the four species of sumac which were being evaluated varied considerably in general growth conditions. Observational studies revealed that *Rhus aromatica* diverged more from the required standards than the other three species. While all of these species were found growing luxuriantly in shaded areas as well as in open sun, fragrant sumac showed more of a tendency to live in dense woods. This fact is revealed when observing a cut-over woods. In southeastern Iowa many small clones of this low shrub dot the cleared areas which once supported dense woods.

The species, *Rhus glabra,* (Fig. 1) a larger shrub than the above mentioned, seldom appears as dense clones in wooded areas but frequents the edges of timber as well as undisturbed fence rows, pasture lands and railroad right-of-ways. Smooth sumac probably covers more acreage in this given area in southeastern Iowa than does fragrant sumac. The more lofty, luxuriant growth and greater spread make *R. glabra* more favorable than *R. aromatica* as a hillculture crop as far as yield of plant material is concerned.

The tendency for *Rhus copallina* to occur farther south than Iowa makes it difficult to compare it with the other three species.

The general tendency for dwarf sumac to grow in lower ground does not favor its propagation on more hilly xeric sites such as are to be found in this area at the extreme northwestern border of its range. Plants of black sumac which were transplanted to planting sites of the Hillculture Farm never showed vigorous growth. Winter-killing was quite frequent either of the aboveground parts or of the entire plant. The only native clones of black sumac recorded in Iowa are located at Lacey-Keosauqua State Park and near Keokuk, Iowa, 30 and 50 miles east of the Floris station respectively (3). A previously unrecorded location of native clones of this species was found two miles north of the Hillculture Experimental Farm.

While *Rhus typhina* is found native in northeastern Iowa it is readily acclimated in southern Iowa as shown by its vigorous growth in experimental plantings. The leaves of this plant are much larger than those of *R. aromatica* or *R. copallina* but are about the same size as those of *R. glabra. Rhus typhina* grows in similar locations to those of *R. glabra.* It seldom migrates far into dense cover but is found at the edge of woods and thickets or along steep rocky banks and roadsides, and, because of its greater height and shade tolerance, competes more successfully with other tall shrubs and with small trees than does *R. glabra.*

Observations indicated that leaves of the four species studied varied considerably in dry weight. It was also noted that the ratio between the weight of the petiole-rachis and that of the attached leaflets varied in these species. Randomized samples were taken on July 23, 1943, of the component parts of the leaves of fragrant, smooth, dwarf and staghorn sumac and weighed to show these differences. The results are recorded in Table 1. The date of sampling has been recorded since it must be realized that the leaves would have a seasonal variation in dry weight.

TABLE 1.—The average dry weight of the component parts of the leaf as compared to the whole in four species of sumac on July 23, 1943.

Species	No. of leaflets	Petiole-rachis (gm.)	Leaflet (gm.)	Leaf (gm.)
Rhus aromatica	3	.007	.052	.163
Rhus copallina	7 to 21	.088	.083	.700
Rhus glabra	11 to 31	.510	.073	3.105
Rhus typhina	9 to 27	.433	.106	2.410

The dry weight of the leaves differ with the species chiefly because of a variation in the number of leaflets. Smooth, black and staghorn sumac range from 7 to 31 while fragrant sumac rarely has more than three leaflets per leaf (1).

One of the natural methods of propagation of sumac is by means of root sprouts. Some species of sumac have a shallow, spreading root system that extends for a considerable distance and from which other sprouts develop. These sprouts are referred to as offshoots, offsets or suckers. It was apparent that there was a difference in the tendency of these four species to produce new growth by this means. Figure 1 shows an excavation in a native clone of *R. glabra*. It can be seen that the roots form a network very close to

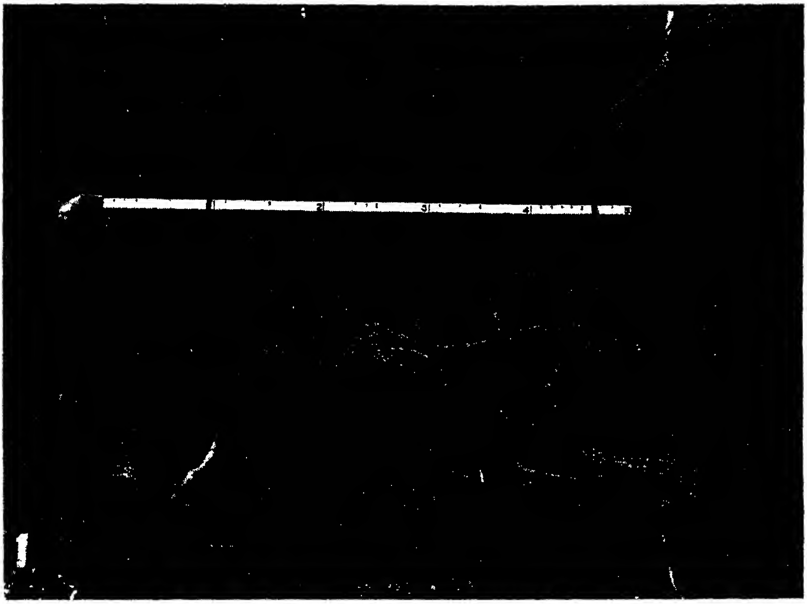


FIGURE 1.—An excavation in a clone (g 12) of *Rhus glabra*. The measuring stick is five feet long.

the surface of the soil. As a means of determining the rate of development of new offshoots six plants of each of the four species of sumac were set out in rows at intervals on an eroded hillside. After a period of five years measurements and counts were made to determine the relative number and distances to which these shoots developed from the original parent plants. Staghorn sumac far exceeded the other three species in total production and distance to which offshoots had extended. The greatest distance that offshoots were found from the original plants of this species was twenty feet. There were 38 of these offshoots produced. *Rhus glabra* produced seventeen offshoots. The most distant sprout was ten feet away.

Twelve offshoots grew around the *R. copallina* original transplants. The most distant sprouts were only nine feet away. In a very short distance from the original transplants of *R. aromatica* nine offshoots came up. None of these offshoots were more than a foot from the original transplants.

At the outset of this research, stands of sumac were established by planting seed which was previously treated with sulfuric acid (2). Stem growth responses of these seedling plants were observed. Stem elongation, root development and dry-weight yield of material were recorded for each species. Figures 2, 3, 4 and 5 are drawings

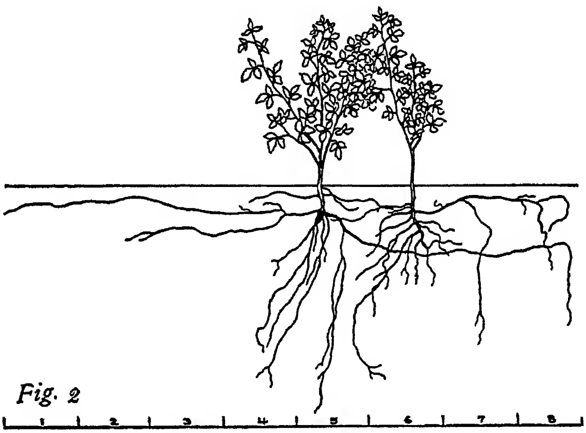


Fig. 2

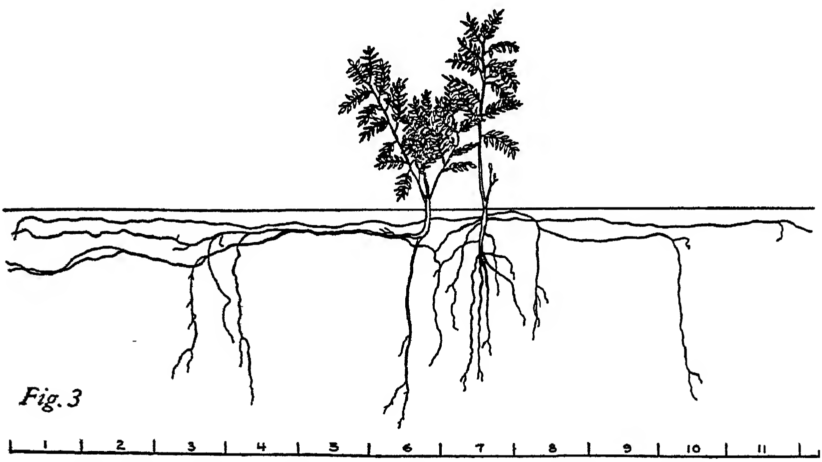
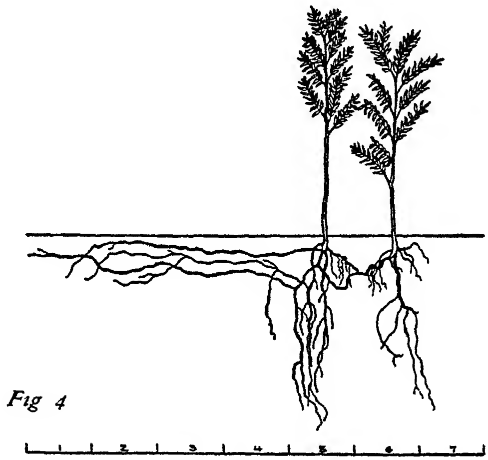


Fig. 3

FIGURE 2.—(Upper) Two-year-old seedlings of *Rhus aromatica* showing the position in which the roots were growing when the plants were excavated.

FIGURE 3.—Two-year-old seedlings of *Rhus copallina* showing the position in which the roots were growing when the plants were excavated.

of the seedlings of these four species of sumac showing the positions of the roots as these plants were dug out of the ground. The lateral roots of all the plants follow very closely to the surface of the soil. Furthermore, the roots were much more extensive than were the above-ground parts of the plants. The fact that these roots ran very close to the surface of the ground should indicate that these plants would be excellent soil conservation plants. Very little difference could be recognized in the underground parts of these species. The roots of *R. aromatica* had slightly more tendency to extend deeper into the soil than did the roots of the other species.



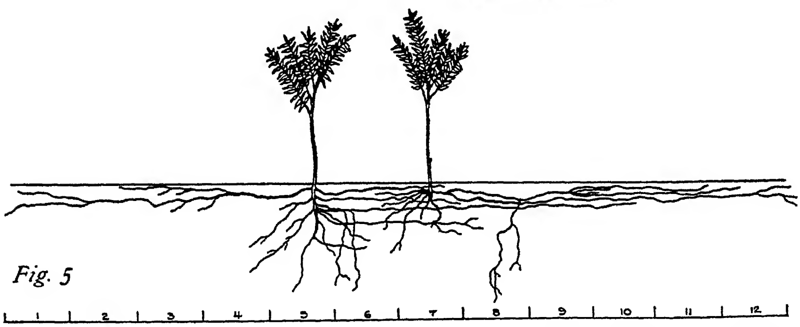
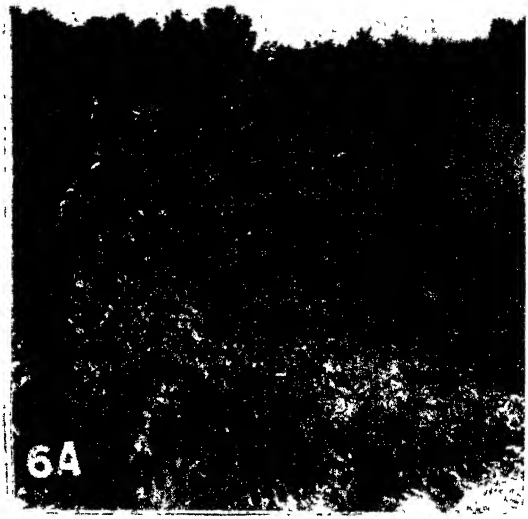


FIGURE 4.—(Upper) Two-year-old seedlings of *Rhus glabra* showing the position in which the roots were growing when the plants were excavated.

FIGURE 5.—Two-year-old seedlings of *Rhus typhina* showing the position in which the roots were growing when the plants were excavated.

In Figure 6 are photographs of sumac planted in the spring of 1939. Figure 6A is a picture of smooth sumac seedlings three



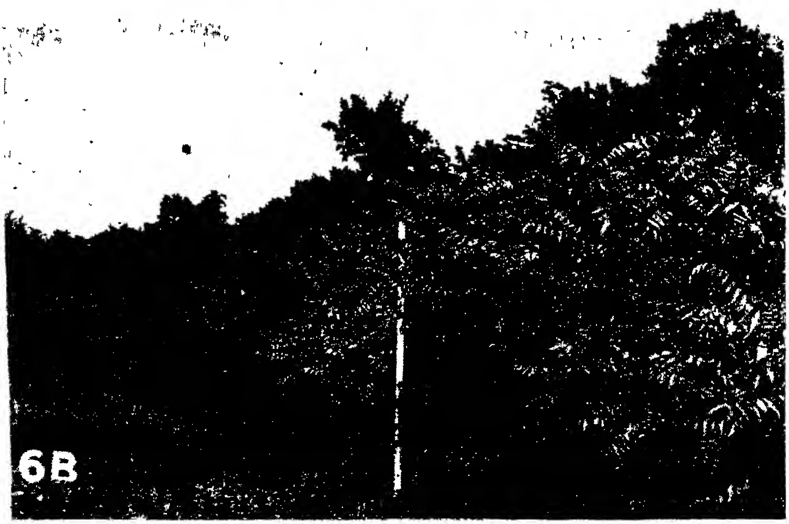


FIGURE 6.—Seedling sumac grown in contour furrows since 1939. (Upper) *Rhus glabra* three years old, 1941. (Lower) *Rhus typhina* four years old, 1942.

FIGURE 7.—Sumac used as roadside plantings along Federal Highway 63, south of Ottumwa, Iowa. (Upper) *Rhus glabra* on a 15 per cent slope. (Lower) *Rhus glabra* and *Rhus typhina* on a 20 per cent slope.

years old. Figure 6B is a photograph of staghorn sumac seedlings four years old. The seedlings were cultivated twice during the first season but were given no further treatment the following years. The measuring stick shown is five feet long.

Late in the summer of 1941 erosion traps were placed in native clones of *R. glabra* to determine the amount of erosion and runoff. The undercover of grass was removed in one trap and left undisturbed in another trap adjacent to the first trap. The water and soil loss in the denuded plot was slightly greater than in the sumac plot in which the grass cover was left undisturbed. In neither case was there an appreciable loss of soil or water. Twenty-two sumac plants were growing in each of these one five-hundredth acre plots.

In the past it was often the custom to clear highways of shrubbery and trees but in more recent years a trend in highway plantings has aided in beautifying these long monotonous stretches with the use of ornamental shrubs and trees. Sumac is often used in these highway plantings especially along steep banks which would otherwise be subject to severe gullying and erosion. The most common sumac species used in Iowa for roadside plantings are smooth and staghorn sumac. Figure 7 shows scenes of sumac plantings growing along Federal Highway Number 63, south of Ottumwa, Iowa. In Figure 7B staghorn plants can be seen growing at the right of the telephone pole. The staghorn plants are one to three feet taller than the more abundant smooth sumac species.

For sane hillculture practice, sumac cannot be considered a valuable, economic tannin plant unless it ranks high as a soil conservation plant. The ultimate purpose in this study was to determine to what extent sumac was capable of fulfilling these two necessary requirements. Under the limited conditions of the tests it was shown that *R. glabra,* at least, meets the qualifications of soil conservation.

Even though some sumac plants may be high in tannin content they may not produce enough material to make harvesting of them practical. Observations showed that one-year-old seedling sumac was much too small to harvest. Second and third year plants of *R. copallina, R. glabra* and *R. typhina* could be harvested. Yield from these seedlings however, was not as high as might be expected from mature plants. These young plants did not bloom until the third year of growth. Plants which were harvested did not bloom or fruit the following year. Lack of fruit was an advantage since the

seeds are difficult to remove and if left in the tan material are seriously objected to by the leather manufacturers.

Table 2 shows the quantity of leaf and stem dry matter, produced on the two-year old seedling sumac strips and calculated on an acre basis. The stems produced the greater amount of material

TABLE 2.—Pounds per acre of dry leaves and stems produced by four species of sumac planted from seed in May, 1940, and harvested on August 25, 1942.

Species	Leaves	Stems
Rhus aromatica	416	772
Rhus copallina	975	2100
Rhus glabra	592	1384
Rhus typhina	2250	1890

in all four instances but this probably would not be a true picture in ordinary harvesting conditions as only the upper parts of the stems bearing leaves would be cut. In the above experiment the stems were cut approximately two inches above the surface of the ground.

Table 3 shows the weights of collections of air-dry sumac leaves taken over a period of three years from smooth sumac clones. Emphasis is placed on *R. glabra* because the investigations indicate it to be the most promising sumac for tannin production in Iowa .

TABLE 3.—Yield tests of air-dry leaf material on smooth sumac *Rhus glabra* taken at different times in the growing season.

No. of clones harvested[1]	Area harvested (sq. ft.)	Date of harvesting	Yield of leaf on acre basis (lbs.)
4	256	June 27, 1940	1172
14	4781	August 3, 1941	1903
1	400	September 1, 1942	1634

[1]Only unit areas were selected from each clone. In no case was an entire clone harvested.

In all cases the yield was more than one-half ton per acre and in 1941 the yield was greater, almost one ton per acre. The harvesting in 1941 was done on August 3. As indicated in Table 3 the maximum yield of leaf material occurred early in August.

From these experiments it may be concluded that favorable response from smooth sumac warrants its use in erosion control and as an economic tannin-producing plant.

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A Checklist of Kansas Mammals, 1943

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Introduction

Since the publication of "A Revised Checklist of Kansas Mammals", (Hibbard, 1933), a number of papers and notes have appeared on Kansas mammals. J. D. Black's, "Mammals of Kansas", 1937, gave an extensive discussion of the characters, habits, economic values and known distributions of the species in Kansas. A key for the identification of these mammals was included for the layman and the elementary student. Black's paper is the best work available on Kansas mammals. Students are referred to Black's paper for information concerning the habits and economic values of these mammals.

Paul Allen's "Kansas Mammals" was published in 1940. It is inadequate, for it is not as complete as Black's paper. Allen's notes are confusing, because he was apparently unable to distinguish between species and subspecies in the discussion of characters, range, etc. His key to Kansas mammals is not usable.

In the past ten years, a number of new subspecies have been described either from Kansas or from adjoining states. These additions have necessitated changes in the names of a number of the mammals occurring in Kansas; revisions have also appeared with resulting changes in the names of some forms. Hibbard, in his 1933 "Revised Checklist", overlooked a number of changes in nomenclature that had come into usage since the publication of Miller's, "List of North American Recent Mammals 1923".

It is hoped that this checklist will serve a useful purpose among the students who work on the anatomy, cytology, histology, parasitology, etc., of Kansas mammals. For such students it is as important that the mammals be correctly identified as it is that the identification of the materials from such mammals be known with certainty. This list also should serve to indicate our lack of knowledge concerning the distribution of Kansas mammals and thereby suggest problems for further study.

In the 1933 checklist much emphasis was placed upon the Flint

Transactions Kansas Academy of Science, Vol. 47, 1944.

Hills as a western barrier to forms occurring in eastern Kansas. The 98th and 99th meridians were considered as a dividing line between many of the eastern and western forms of Kansas mammals. The past ten years of study have presented an entirely different picture of mammalian distribution in Kansas. When the distribution of these mammals is thoroughly understood it will probably be found that the range of eastern mammals will extend far westward up the major stream valleys, while the western forms will pass the westward extension of the eastern forms and finger eastward down the upland divides. The ranges of the eastern and western forms will be much like interlocking fingers, one arm representing the stream and the hand with its fingers serving as the tributaries. The other arm and hand with its fingers would then represent a major divide and its upland divides between the tributary streams.

Merriam (1898) defined life zones of animal and plant life in North America, and in some cases animal life in Kansas has been assigned to these life zones. Smith (1934, p. 383) in his study of "The Amphibians of Kansas" found that in distribution the amphibians of Kansas more nearly paralleled the physiographic regions of Fenneman (1928) than they did the life zones of Merriam. Dice (1943) described and discussed the biotic provinces of North America and presented a map showing the provinces under discussion. Dice defines a *biotic district,* "as a subdivision covering a definite and continuous part of the geographic area of a biotic province." At present there is not enough known concerning the distribution of the animal and plant life to make possible an accurate and detailed map of the biotic districts of Kansas. Blair and Hubell (1938) described the biotic districts of Oklahoma. The biotic districts of the northern part of Oklahoma will extend northward into Kansas, but the limits of their boundaries within the state are not known.

Class MAMMALA

Subclass EUTHERIA

Order MARSUPIALIA

Family DIDELPHIIDAE

Didelphis virginiana virginiana Kerr. Virginia Opossum.

1792. *Didelphis virginiana* Kerr, Anim. Kingd., p. 193.

TYPE LOCALITY.—Virginia.

Occurrence.—The opossum occurs throughout the State, chiefly along streams, although it is often found far from timber, living on treeless plains.

Order Insectivora

Family Talpidae. Moles.

Scalopus aquaticus caryi Jackson. Northern Plains Mole.

1914. *Scalopus aquaticus caryi* Jackson, Proc. Biol. Soc. Wash., Vol. 27, p. 20.

Type Locality.—Neligh, Antelope County, Nebraska.

Occurrence.—This mole is known from the shaded and moist areas in northwestern Kansas. Limit of range in the State is unknown.

Scalopus aquaticus intermedius Elliot. Southern Plains Mole.

1899. *Scalopus machrinus intermedius* Elliot, Field Columb. Mus., Pub. 37, Zool. Soc., Vol. 1, p. 280.

Type Locality.—Alva, Woods County, Oklahoma.

Occurrence.—The range of the Southern Plains Mole extends northward into southwestern Kansas. The limit of its range within the State is not known.

Scalopus aquaticus machrinoides Jackson. Missouri Valley Mole.

1914. *Scalopus aquaticus machrinoides* Jackson, Proc. Biol. Soc. Wash., Vol. 27, p. 19.

Type Locality.—Manhattan, Riley County, Kansas.

Occurrence.—This mole is common throughout the eastern half of the State. How far it extends westward up the valleys of the Smoky Hill and Republican rivers is not known.

Family Soricidae. Shrews.

Cryptotis parva parva (Say). Small Shrew.

1823. *Sorex parvus* Say, Long's Exped. Rocky Mts., Vol. 1, p. 163.

Type Locality.—West bank of Missouri river, near Blair, formerly Engineer Cantonment, Washington County, Nebraska.

Occurrence.—This shrew inhabits the grasslands of the entire State. Though more abundant in the eastern half, it is confined chiefly to the more moist meadows in the western half of the State.

Blarina brevicauda brevicauda (Say). Short-tailed Shrew.

1823. *Sorex brevicadus* Say, Long's Exped. Rocky Mts., Vol. 1, p. 164.

Type Locality.—West bank of Missouri river, near Blair, formerly Engineer Cantonment, Washington County, Nebraska.

Occurrence.—The Short-tailed shrew is known only from the timbered and lowland regions of northeastern Kansas. It should extend westward along the timbered river valleys.

Blarina brevicauda hulophaga Elliot. Woodland Shrew.

1899. *Blarina brevicauda hulophaga* Elliot, Field Columb. Mus., Publ. 38, Zool. Ser., Vol. 1, p. 287.

Type Locality.—Dougherty, Murray County, Oklahoma.

Occurrence.—The Woodland Shrew is found in the wooded

areas of southeastern Kansas. J. D. Black (1937, p. 142) and Paul Allen (1940, p. 20) referred to this form as *B. b. carolinensis* (Bachman).

Order CHIROPTERA. Bats.

Family VESPERTILIONIDAE

Myotis lucifugus lucifugus (LeConte). Little Brown Bat.

1831. *Vespertilio lucifugus* LeConte, McMurtrie's Cuvier, Animal Kingdom, Vol. 1, p. 431.

TYPE LOCALITY.—Georgia; probably the LeConte plantation, near Riceboro, Liberty County.

Occurrence.—The Little Brown Bat is known at present only from eastern Kansas, except a single specimen from Barber County.

Myotis subulatus subulatus (Say). Small-winged Bat.

1823. *Vespertilio subulatus* Say, Long's Exped. Rocky Mts., Vol. 2, p. 65.
1886. *Vespertilio ciliolabrum* Merriam, Proc. Biol. Soc. Wash., Vol. 4, p. 2. (Type locality near Banner, Trego County, Kansas, in a bluff on Hackberry creek, about one mile from Castle Rock)

TYPE LOCALITY.—Arkansas river, near La Junta, Otero County, Colorado.

Occurrence.—This small bat inhabits the cracks and crevices of the chalk bluffs of western Kansas along the Smoky Hill river and its tributaries.

Myotis velifer incautus (Allen). Cave Bat.

1896. *Vespertilio incautus* Allen, Bull. Amer. Mus. Nat. Hist, Vol. 8, p. 239.

TYPE LOCALITY.—San Antonio, Bexar County, Texas.

Occurrence.—The Cave Bat inhabits the gypsum caves of south-central Kansas along the Oklahoma line.

Lasionycteris noctivagans (LeConte). Silver-haired Bat.

1831. *Vespertilio octivagans* LeConte, McMurtrie's Cuvier, Animal Kingdom, Vol. 1, p. 431.

TYPE LOCALITY.—Eastern United States.

Occurrence.—Only two specimens have been recorded from Kansas, one from Douglas County and the other from Wakeeney, Trego County, Kansas.

Pipistrellus subflavus subflavus (F. Cuvier). Georgian Bat.

1832. *Vespertilio subflavus* F. Cuvier, nouv. ann. mus. hist. nat. Paris, Vol. 1, p. 17.

TYPE LOCALITY.—Eastern United States, probably Georgia.

Occurrence.—The Georgian Bat has been taken in caves from Barber, Butler and Leavenworth Counties in Kansas.

Eptesicus fuscus fuscus (Beauvois). Big Brown Bat.

1796. *Vespertilio fuscus* Beauvois, Catal. Raisonné Mus. Peale, Philadelphia, p. 18.

TYPE LOCALITY.—Philadelphia, Pennsylvania.

Occurrence.—This subspecies of the Brown Bat inhabits eastern Kansas. During the winter months it is found in small numbers in the caves of south-central Kansas, where it replaces the paler race, the Pale Brown Bat, which is found in small numbers in the caves in the summer and early fall.

Eptesicus fuscus pallidus Young. Pale Brown Bat.

1908. *Eptesicus pallidus* Young, Proc. Acad. Nat. Sci. Philadelphia, p. 408.

TYPE LOCALITY.—Boulder, Boulder County, Colorado.

Occurrence.—This bat is common in western Kansas where it is found breeding in the attics of buildings. A large colony was observed at Medicine Lodge, Kansas, in association with the Mexican Free-tailed Bat (see Hibbard, 1936). The bat migrates southward in the winter and is known to be replaced in part of its eastern range during the winter months by the darker race from the northeast which moves southward.

Lasiurus borealis borealis (Müller). Red Bat.

1776. *Vespertilio borealis* Müller, Natursyst. Suppl, p 20

1931. *Lasiurus borealis* Miller, Jour. Mammalogy, Vol. 12, pp. 409-410.

TYPE LOCALITY.—New York.

Occurrence.—Found throughout Kansas where there are trees, in the late spring, summer and early fall.

Lasiurus cinereus (Beauvois). Hoary Bat.

1796 *Vespertilio cinereus* (misspelled *linereus*) Beauvois, Catal. Raisonné Mus Peale, Philadelphia, p. 18 (*fide* Miller, p. 79, 1924).

TYPE LOCALITY.—Philadelphia, Pennsylvania.

Occurrence.—The Hoary Bat occurs throughout Kansas during the summer months where there are trees, its range in the State being the same as that of the Red Bat, though not as common. Both of these bats rear their young in Kansas.

Corynorhinus rafinesquii pallescens Miller. Pallid-eared Bat.

1897. *Corynorhinus macrotis pallescens* Miller, North Amer. Fauna, No. 13, p. 52.

TYPE LOCALITY.—Keams Canyon, Navajo County, Arizona.

Occurrence.—These long-eared bats are known from the gypsum caves of Barber and Comanche counties, Kansas.

Antrozous bunkeri Hibbard. Bunker's Bat.

1934. *Antrozous bunkeri* Hibbard, Jour. Mammalogy, Vol. 15, No. 3, p. 227.

TYPE LOCALITY.—Natural Bridge 5½ miles south of Sun City, Barber County, Kansas.

Occurrence.—Bunker's Bat is known only from the type locality

in Kansas, which is the Natural Bridge in Barber County. At this place there exists an old cave below and to the west side of the Natural Bridge, which has been dissected by the present stream. It is not an "irrigation tunnel at a Natural Dam" as reported by Black (1937, p. 152).

Nothing is known of the habits of the bat and its distribution in Kansas. So far it seems that the occurrence at the type locality is during migration. In addition to the type series taken September 2, 1933, 81 specimens were collected on August 31, 1935; these were chiefly adult females, and immature females; a few immature males were taken. September 9, 1939, eight specimens were collected from a colony of more than 300 by Walter Yost and myself. No adult males have been taken.

Family MOLOSSIDAE

Tadarida mexicana (Saussure). Mexican Free-tailed Bat.

1860. *Molossus mexicanus* Saussure, Revue et Magasin de Zoologie, Ser. 2, Vol. 12, p. 283.

TYPE LOCALITY.—Ameca, Jalisco, Mexico.

Occurrence.—This bat is found breeding in the attics of the large buildings of south-central Kansas. It migrates southward for the winter. Undoubtedly it was this bat and not *Tadarida cynocephala* (LeConte) that Ruby M. Macy and Ralph Macy (1939, p. 252) recorded as occurring at the Marehew cave, Woods County, Oklahoma, just across the Kansas line.

Order CARNIVORA

Family URSIDAE. Bears

Euarctos americanus americanus (Pallas). Black Bear.

1780. *Ursus americanus* Pallas, Spicilegia Zoologica, fasc 14, p 5.

TYPE LOCALITY.—Eastern North America.

Occurrence.—This bear was once common in the eastern portion of Kansas. Now extinct in the State.

Euarctos americanus amblyceps (Baird). New Mexico Black Bear.

1859. *Ursus amblyceps* Baird, Rep. U. S. and Mex. Bound. Surv., Vol. 2, pt. 2, p. 29.

TYPE LOCALITY.—Fort Webster, on the Gila river, lat. 32° 47′, long. 108° 4′; Grant County, New Mexico.

Occurrence.—In the early days this bear was common in south-central Kansas where it inhabited the gypsum caves. It also occurred northward of this area in Kiowa county and extended westward to

the Colorado line. There is one record of a black bear having been killed just south of Meade in a small canyon. Now extinct in the State.

Ursus horribilis horribilis Ord. Plains Grizzly.

1815. *Ursus horribilis* Ord, Guthrie's Geography, 2nd Amer. ed., Vol. 2, p 291, described on p 299.

TYPE LOCALITY.—Missouri river, a little above mouth of Poplar river, northeastern Montana.

Occurrence.—The Plains Grizzly was once common throughout western Kansas, where it followed the bison herds to feed on the sick and the stragglers. One skull has been examined from Council Grove, Morris County, Kansas, in the mammal collection at the Kansas State Agricultural College, Manhattan, Kansas.

Family PROCYONIDAE

Procyon lotor hirtus Nelson and Goldman. Missouri Valley Raccoon.

1930. *Procyon lotor hirtus* Nelson and Goldman, Jour. Mammalogy, Vol. 11, No. 4, p. 455.

TYPE LOCALITY.—Elk river, Sherburne County, Minnesota.

Occurrence.—Raccoons are common along the streams throughout the State, especially the western part. They live in caves, in Barber and Comanche counties, and in holes in the bluffs in the treeless areas. The raccoon of southwestern Kansas is grayer than the raccoon of eastern Kansas.

Family MUSTELIDAE

Mustela frenata longicauda Bonaparte. Long-tailed Weasel.

1838. *Mustela longicauda* Bonaparte, Charlesworth's Mag. Nat. Hist. Vol. 2, p. 38.

1936. *Mustela frenata longicauda* Hall, Carnegie Inst. Wash. Publ, No 473, p. 105.

TYPE LOCALITY.—Carlton House, on North Saskatchewan river, Saskatchewan, Canada.

Occurrence.—This is the weasel, so commonly seen in Kansas, that is white in the winter with a black tip on its tail. It is found west of the Flint Hills in Kansas. (See Hall, p. 101, fig. 6, 1936).

Mustela frenata neomexicana (Barber and Cockerell). New Mexico Bridled Weasel.

1898. *Putorius frenatus neomexicanus* Barber and Cockerell, Proc. Acad. Nat. Sci Philadelphia, p. 188.

TYPE LOCALITY.—Armstrong's Lake, Mesilla Valley, Donna Ana County, New Mexico.

Occurrence.—Only one specimen of this weasel is known to have been taken in Kansas. It was obtained at Liberal, Stevens County,

November 1, 1889. Range probably extreme southwest corner of the State.

Mustela frenata primulina Jackson. Missouri Weasel.

1913. *Mustela primulina* Jackson, Proc. Biol. Soc. Wash., Vol. 26, p. 123.

TYPE LOCALITY.—Five miles northeast of Avilla, Jasper County, Missouri.

Occurrence.—This weasel inhabits eastern Kansas.

Mustela vison letifera Hollister. Mississippi Valley Mink.

1913. *Mustela vison letifera* Hollister, Proc. U. S. Nat. Mus., Vol. 44, p. 475.

TYPE LOCALITY.—Elk river, Sherburne County, Minnesota.

Occurrence.—Mink occurred at one time throughout the State along the streams. Now rare, and rapidly becoming extinct.

Mustela nigripes (Audubon and Bachman). Black-footed Ferret.

1851. *Putorius nigripes* Audubon and Bachman, Quadr. N. Amer. Vol 2, p. 297.

TYPE LOCALITY.—Fort Laramie, Laramie County, Wyoming.

Occurrence.—Due to the destruction of most of the prairie-dog towns in Kansas the Black-footed Ferret is now on the verge of extinction in the State.

Lutra canadensis cf. *interior* Swenk. Otter.

1920. *Lutra canadensis interior* Swenk. Univ. Studies, Univ. of Nebraska, Vol. 18, 1918, No. 1, p. 2.

TYPE LOCALITY.—Lincoln creek, west of Seward, Seward County, Nebraska.

Occurrence.—The otter was once common throughout the State along the streams with running water, but is now extinct in Kansas. Due to the scarcity of material in the collection it is not known whether the specimens from Kansas are referable with certainty to *L. c. interior* Swenk, or *L. c. texensis* Goldman.

Spilogale interrupta (Rafinesque). Little Spotted Skunk.

1820. *Mephitis interrupta* Rafinesque, Annals of Nature. Vol. 1, p. 3

TYPE LOCALITY.—Upper Missouri. (See Miller, 1924, p. 133).

Occurrence.—This little skunk is common throughout most of the State.

Mephitis mephitis avia Bangs. Illinois Skunk.

1898. *Mephitis avia* Bangs, Proc. Biol. Soc. Wash , Vol. 12, p. 32.
1936. *Mephitis mephitis avia* Hall, Carnegie Inst. Wash. Publ. No. 473, p. 65.

TYPE LOCALITY.—San Jose, Mason County, Illinois.

Occurrence.—Chiefly northeastern Kansas, extending westward up the Kansas river, south to Greenwood County where it intergrades with *M. m. mesomelas.*

Mephitis mephitis mesomelas Lichtenstein. Eastern Skunk.

1832. *Mephitis mesomelas* Lichtenstein, Darstellung neuer oder wenig bekannter Säugethiere, pl. 45, fig. 2.
1936. *Mephitis mephitis mesomelas* Hall, Carnegie Inst. Wash. Publ. No. 473, p. 66.

TYPE LOCALITY.—Louisiana.

Occurrence.—Range extreme southeastern Kansas. Some specimens from Greenwood County are typical.

Mephitis mephitis varians Gray. Long-tailed Skunk.

1837. *Mephitis varians* Gray, Charlesworth's Mag. Nat. Hist., Vol. 1, p. 581.
1936. *Mephitis mephitis varians* Hall, Carnegie Inst. Wash. Publ. No. 473, p. 66.

TYPE LOCALITY.—Texas.

Occurrence.—Ranges west of Flint Hills; on the east, it intergrades with the Illinois Skunk.

Taxida taxus taxus (Schreber). Common Badger.

1778. *Ursus taxus* Schreber, Säugethiere, Vol. 3, p. 520.

TYPE LOCALITY.—Labrador and Hudson Bay.

Occurrence.—The badger is found chiefly west of the Flint Hills, though it is well established east of them in certain areas such as Greenwood County. All of the badgers are referred to the above form, though throughout southern Kansas many badgers are found that possess a dorsal white stripe running posteriorly to the middle of the back and in some specimens extending to the tail. This locality is probably on the edge of the area of intergradation with *T. t. berlandieri* Baird.

Family CANIDAE

Vulpes fulva fulva (Desmarest). Red Fox.

1820. *Canis fulvus* Desmarest, Mammalogie, Vol. 1, p. 203.

TYPE LOCALITY.—Virginia.

Occurrence.—How far west the range extends is unknown. Mr. A. M. Brooking, of the Hastings Nebraska Museum, reports a Red Fox in their collection that was taken near Waconda Springs, Mitchell County, Kansas. The specimen was killed June 3, 1943, and was one of a pair of foxes with young. The Red Fox has been released at a number of places in western Kansas. They have been seen in Meade County where they escaped from the pens at Meade County State Park.

Vulpes velox velox (Say). Swift Fox.

1823. [*Canis*] *velox* Say, Long's Exped. Rocky Mts., Vol. 1, p. 487.

TYPE LOCALITY.—South Platte river, Colorado. (See Miller, 1924, p. 146).

Occurrence.—This fox is becoming rare in western Kansas.

Urocyon cinereoargenteus ocythous Bangs. Gray Fox.

1899. *Urocyon cinereoargenteus ocythous* Bangs, Proc. New England Zool. Club, Vol. 1, p. 43.

Type Locality.—Platteville, Grant County, Wisconsin.

Occurrence.—The Gray Fox occurs in the wooded areas of eastern Kansas. It is common in northeastern Kansas, but rare in the southeastern part of the State, where it was once plentiful.

Canis latrans Say, Say's Coyote.

1823. *Canis latrans* Say, Long's Exped. Rocky Mts., Vol. 1, p. 168.

Type Locality.—Engineer Cantonment, near present town of Blair, Washington, County, Nebraska.

Occurrence.—Say's Coyote is common throughout eastern Kansas and its range meets that of the Nebraska Coyote in the western part of the State.

Canis latrans nebracensis Merriam. Nebraska Coyote.

1898. *Canis nebracensis* Merriam, Science, N. S., Vol. 8, p. 792. (Substitute for *pallidus* Merriam, Proc. Biol. Soc. Wash., 1897, Vol. 11, p. 24).

Type Locality.—Johnstown, Brown County, Nebraska.

Occurrence.—The Nebraska Coyote is found throughout western Kansas with the exception of the extreme southwestern corner of the State, where its range meets that of *C. l. texensis* Bailey.

Canis latrans texensis Bailey. Texas Coyote.

1905. *Canis nebracensis texensis* Bailey, North Amer. Fauna, No. 25, p. 175. (Substitute for *Canis frustror* Merriam, Proc. Biol. Soc. Wash., 1897, Vol. 11, p. 26).
1932. *Canis latrans texensis* Nelson, Proc. Biol. Soc. Wash., Vol. 45, p. 224.

Type Locality.—Forty-five miles southwest of Corpus Christi, Nueces County, Texas.

Occurrence.—This coyote occurs in the extreme southwestern corner of Kansas, from western Barber County to the Colorado line.

Canis niger rufus Audubon and Bachman. Texas Red Wolf.

1851. *Canis lupus* var. *rufus* Audubon and Bachman, Quadr. N. Amer., Vol. 2, p. 240.
1852. *Canis frustror* Woodhouse, Proc. Acad. Nat. Sci. Philadelphia, Vol. 5, p. 147. (*Fide* Blair, 1939, p. 108).
1905. *Canis rufus* Bailey, North Amer. Fauna, No. 25, p. 174.
1942. *Canis niger rufus* Harper, Jour. Mammology, Vol. 23, No. 3, p. 339.

Type Locality.—Fifteen miles west of Austin, Texas.

Occurrence.—At one time the Texas Red Wolf was common in southern Kansas. The last record was of one killed by Clyde Boyd near Columbus, Cherokee County, in 1909.

Canis lupus nubilus Say. Gray Wolf.

1823. *Canis nubilus* Say, Long's Exped. Rocky Mts., Vol. I, p. 169.
1937. *Canis lupus nubilus* Goldman, Jour. Mammology, Vol. 18, No. 1, pp. 37, 45.

TYPE LOCALITY.—Engineer Cantonment, near present town of Blair, Washington County, Nebraska.

Occurrence.—The Gray Wolf was once common throughout the State. It is now extinct in Kansas.

Family FELIDAE. Cats.

Felis concolor couguar Kerr. "Panther."

1792. *Felis couguar* Kerr, Anim. Kingd., p. 151.
1929. *Felis concolor couguar* Nelson and Goldman, Jour. Mammalogy, Vol. 10, No. 4, p. 347.

TYPE LOCALITY.—Pennsylvania.

Occurrence.—Once common in eastern Kansas at time of early settlement, but now extinct in the State.

Felis concolor hippolestes Merriam. Rocky Mountain Lion.

1897. *Felis hippolestes* Merriam, Proc. Biol. Soc. Wash., Vol. 11, p. 219.
1929. *Felis concolor hippolestes* Nelson and Goldman, Jour. Mammalogy, Vol. 10, No. 4, p. 347.

TYPE LOCALITY.—Wind River Mountains, Fremont, County, Wyoming.

Occurrence.—The mountain lion once occurred in western Kansas. I have talked with a number of the "Old Timers," who tell of the poison used to kill them when the country was first settled. I have heard two accounts of large spotted cats being killed in Meade County. From careful checking, they must have been immature specimens. The last record for the state was a lion killed August 15, 1904, in Ellis County, by William Applebaugh and J. H. Spratt.

Lynx rufus rufus (Schreber). Wild Cat, Bobcat.

1777. *Felis rufa* Schreber, Säugethiere, pl. 109b.

TYPE LOCALITY.—New York.

Occurrence.—The bobcat is decreasing in number in eastern Kansas.

Lynx rufus baileyi Merriam. Plateau Bobcat.

1890. *Lynx baileyi* Merriam, North Amer. Fauna, No. 3, p. 79.
1924. *Lynx ruffus baileyi* Grinnell and Dixon, Univ. Calif. Publ. Zool., Vol. 21, No. 13, p. 349.

TYPE LOCALITY.—Moccasin Spring, Coconino County, Arizona.

Occurrence.—This bobcat is found chiefly west of the Flint Hills and especially along the Oklahoma border in the region of the gypsum caves.

Order RODENTIA

Family SCIURIDAE

Marmota monax bunkeri Black. Bunker's Woodchuck.

1935. *Marmota monax bunkeri* Black, Jour. Mammalogy, Vol. 16, No. 4, p. 319.

TYPE LOCALITY.—Seven miles southwest of Lawrence, Douglas County, Kansas.

Occurrence.—Range northeastern Kansas extending westward along the Kansas river and tributaries. Woodchucks are known to occur as far south as Woodson and Greenwood counties.

Cynomys ludovicianus ludovicianus (Ord). Prairie Dog.

1815. *Arctomys ludoviciana* Ord, Guthrie's Geography, 2nd Amer. ed., Vol. 2, p. 292. Description on page 302.

TYPE LOCALITY.—Upper Missouri river ("vicinity of the Missouri, and throughout the greater part of Louisiana").

Occurrence.—The Prairie Dog was once common in the short grass region of Kansas. A few small isolated towns still exist on some of the larger ranches, although they have been greatly decreased in number during the past ten years, by an intensive movement to exterminate them.

Citellus tridecemlineatus tridecemlineatus (Mitchill). Thirteen-lined Ground Squirrel.

1821. *Sciurus tridecem-lineatus* Mitchill, Med. Repository, n. s., Vol. 6. No. 21, p. 248.

TYPE LOCALITY.—Central Minnesota.

Occurrence.—This ground squirrel occurs in the grasslands of northeastern Kansas. It intergrades on the west with *C. t. pallidus* and on the south with *C. t. texensis*. .

Citellus tridecemlineatus arenicola Howell. Sandhill Striped Ground Squirrel.

1928. *Citellus tridecemlineatus arenicola* Howell, Proc. Biol. Soc. Wash., Vol. 41, p. 213.

TYPE LOCALITY.—Pendennis, Lane County, Kansas.

Occurrence.—Southwestern Kansas; at the type locality it intergrades with *C. t. pallidus.*

Citellus tridecemineatus pallidus (Allen). Pallid Striped Ground Squirrel.

1877. [*Spermophilus tridecemlineatus*] var. *pallidus* Allen, Monogr. N. Amer. Rodentia, p. 872.

TYPE LOCALTY.—Mouth of the Yellowstone river, Montana. (See A. H. Howell, 1938, p. 112).

Occurrence.—The Pallid Striped Ground Squirrel occurs in northwestern Kansas.

Citellus tridecemlineatus texensis (Merriam). Texas Striped Ground Squirrel.

1898. *Spermophilus tridecemlineatus texensis* Merriam, Proc. Biol. Soc. Wass., Vol. 12, p. 71.

TYPE LOCALITY.—Gainesville, Cooke County, Texas.

Occurrence.—This ground squirred is found in the grasslands of southeastern and south-central Kansas.

Citellus spilosoma major (Merriam). New Mexico Spotted Ground Squirrel.

1890. *Spermophilus spilosoma major* Merriam, N. Amer. Fauna, No. 4, p. 39.

TYPE LOCALITY.—Albuquerque, Bernalillo County, New Mexico.

Occurrence.—Range in Kansas chiefly along the sagebrush flats of the Cimarron river in southwestern Kansas. Specimens have been taken in wheat fields and in pastures on the upland near Plains, Meade County, Kansas.

Citellus spilosoma obsoletus (Kennicott). Kennicott's Spotted Ground Squirrel.

1863. *Spermophilus obsoletus* Kennicott, Acad. Nat. Sci. Phila. Proc., p. 157.
1938. *Citellus spilosoma obsoletus* Howell, N. Amer. Fauna. No. 56, p. 130.

TYPE LOCALITY.—Fifty miles west of Fort Kearney, Nebraska. (See Howell, 1938, p. 131).

Occurrence.—Known only from the extreme northwestern corner of Kansas.

Citellus franklinii (Sabine). Franklin's Ground Squirrel.

1822 *Arctomys franklinii* Sabine, Trans. Linn. Soc. London, Vol. 13, p. 587.

TYPE LOCALITY.—Vicinity of Carlton House, Saskatchewan, Canada.

Occurrence.—This large gray ground squirrel is found in eastern Kansas.

Tamias striatus griseus Mearns. Gray Striped Chipmunk.

1891. *Tamias striatus griseus* Mearns, Bull Amer. Mus. Nat. Hist., Vol. 3, p. 231.

TYPE LOCALITY.—Fort Snelling, Hennepin County, Minnesota.

Occurrence.—This chipmunk occurs along the edge of the wooded areas and ravines of northeastern Kansas.

Tamias striatus venustus Bangs. Southern Chipmunk.

1896. *Tamias striatus venustus* Bangs, Proc. Biol. Soc. Wash., Vol. 10, p. 137.

TYPE LOCALITY.—Stilwell, Adair County, Oklahoma.

Occurrence.—This chipmunk occurs in the wooded areas of extreme southeastern Kansas.

Sciurus carolinensis carolinensis Gmelin. Gray Squirrel.

1788. [*Sciurus*] *carolinensis* Gmelin, Syst. Nat., Vol. 1, p. 148.

TYPE LOCALITY.—"Carolina."

Occurrence.—The Gray Squirrel occurs along the heavily wooded hillsides of eastern Kansas and extends westward along the Kansas river and its tributaries. The westward limit of its range is unknown.

Sciurus niger rufiventer Geoffroy. Fox Squirrel.

1803. *Sciurus rufiventer* Geoffroy, Catal. Mamm. Mus. Nat. Hist., Paris, p. 176.

TYPE LOCALITY.—Mississippi Valley, exact locality not known. (See Bole and Moulthrop, 1942, p. 139).

Occurrence.—The Fox Squirrel is found along the wooded streams of Kansas, becoming paler toward the extreme western part of the State.

Glaucomys volans nebrascensis (Swenk). Nebraska Flying Squirrel.

1915. *Pteromys volans nebrascensis* Swenk, Univ. Studies Nebr., Vol. 15, No. 2, p. 151.

TYPE LOCALITY.—Nebraska City, Otoe County, Nebraska.

Occurrence.—This flying squirrel has long been considered the same as *G. volans volans*. Swenk's characters for separating it from the eastern form are valid, as it averages larger in size, is paler in color, and no winter specimens examined have been observed to possess white hind feet. Known from the wooded areas of eastern Kansas.

Family GEOMYIDAE. Pocket Gophers.

Geomys bursarius majusculus Swenk. Greater Prairie Pocket Gopher.

1939. *Geomys bursarius majusculus* Swenk, Missouri Valley Fauna, No. 1, p. 6.

TYPE LOCALITY.—Lincoln, Lancaster County, Nebraska.

Occurrence.—This pocket gopher occurs in fields and grasslands of northeastern Kansas.

Geomys lutescens lutescens Merriam. Yellow Pocket Gopher.

1890. *Geomys bursarius lutescens* Merriam, N. Amer. Fauna, No. 4, p. 51.
1940. *Geomys lutescens* Swenk, Missouri Valley Fauna No. 2, p. 4.

TYPE LOCALITY.—Sandhills on Birdcreek, Lincoln County, Nebraska.

Occurrence.—The Yellow Pocket Gopher occurs in northwestern Kansas.

Geomys lutescens jugossicularis Hooper. Hooper's Yellow Pocket Gopher.

1940. *Geomys lutescens jugossicularis* Hooper, Occas. Pap. Mus. Zool. Univ. Mich. No. 420, p. 1.

TYPE LOCALITY.—Lamar, Prowers County, Colorado.

Occurrence.—This gopher occurs in the extreme southwestern part of Kansas, and its range meets that of *Geomys l. lutescens* to the north.

Geomys lutescens major Davis. Plains Pocket Gopher.

1940. *Geomys lutescens major* Davis, Texas Agric. Experiment Station Bull. No. 590, p. 32.

TYPE LOCALITY.—Eight miles west of Clarendon, Donley County, Texas.

Occurrence.—This gopher occurs in Clark, Comanche, Barber and Kiowa Counties, Kansas. The full extent of its range in Kansas is not known. Previously it was considered as *Geomys breviceps llanensis* Bailey.

Geomys breviceps cf. *dutcheri* Davis. Oklahoma Pocket Gopher.

1940. *Geomys breviceps dutcheri* Davis, Texas Agric. Experiment Station Bull. No. 590, p. 12.

TYPE LOCALITY.—Fort Gibson, Muskogee County, Oklahoma.

Occurrence.—The gophers of extreme southeastern Kansas and along the Arkansas Valley of southeastern Kansas are referred to this species.

Cratogeomys castanops (Baird). Chestnut-faced Pocket Gopher.

1852. *Pseudostoma castanops* Baird, Report Stansbury's Exped. to Great Salt Lake, p. 313.

TYPE LOCALITY.—"Prairie road to Bent's Fort," near the present town of Las Animas, Bent County, Colorado, on the Arkansas river.

Occurrence.—This gopher was reported by George C. Rinker (1941, p. 88) from a recent skull collected in Meade County in the summer of 1940. Rinker collected another skull of this gopher in the summer of 1942 in Meade County, on a fresh mound of dirt thrown up by *Geomys lutescens* where the skull had been thrown out by the latter. Extensive trapping has been done to locate a colony of these gophers in southwestern Kansas. To date no specimens have been caught.

Family HETEROMYIDAE. Pocket Mice.

Perognathus flavescens flavescens Merriam. Plains Pocket Mouse.

1889. *Perognathus fasciatus flavescens* Merriam, N. Amer. Fauna, No. 1, p. 11.

TYPE LOCALITY.—Kennedy, Cherry County Nebraska.

Occurrence.—Found throughout western Kansas. Eastern ex-

tension of range in Kansas unknown. In extreme southwestern Kansas it probably intergrades with *P. flavescens copei* Rhoads.

Perognathus flavus flavus Baird. Baird's Pocket Mouse.

1855. *Perognatus* [sic] *flavis* Baird, Proc. Acad. Nat. Sci. Philadelphia, Vol. 7, p. 332.

TYPE LOCALITY.—El Paso, El Paso County, Texas.

Occurrence.—This little pocket mouse occurs in southwestern Kansas. The extent of its range in the State is unknown.

Perognathus hispidus paradoxus Merriam. Kansas Pocket Mouse.

1889. *Perognathus paradoxus* Merriam, N. Amer. Fauna, No. 1, p. 24.

TYPE LOCALITY.—Banner, Trego County, Kansas.

Occurrence.—The Kansas pocket mouse inhabits the whole of the State west of the 98th meridian. To the east its range meets that of *P. h. spilotus* Merriam.

Perognathus hispidus spilotus Merriam. Oklahoma Pocket Mouse.

1889. *Perognathus paradoxus spilotus* Merriam, N. Amer. Fauna, No. 1, p. 25.

1903. *Perognathus hispidus maximus* Elliot, Field Columb. Mus. Publ. 87, Zool. Ser., Vol. 3, p. 253.

TYPE LOCALITY.—Gainesville, Cooke County, Texas.

Occurrence.—The Oklahoma Pocket Mouse ranges from Cowley County northward along the Flint Hill region to northern Riley County. It has been taken as far east as Woodson County.

Dipodomys ordii richardsoni (Allen). Five-toed Kangaroo Rat.

1891. *Dipodops richardsoni* Allen, Bull. Amer. Mus. Nat. Hist., Vol. 3, p. 277.

TYPE LOCALITY.—"One of the sources of the Beaver [North Canadian] river in the extreme northwestern corner of the [Indian] territory of the so-called Neutral Strip." Probably Harper County, Oklahoma (Blair, 1939, p. 116).

Occurrence.—The kangaroo rat is common throughout the sandy areas of the western part of Kansas. Its range extends northeastward along the Kansas river into Riley County.

Family CASTORIDAE. Beaver.

Castor canadensis missouriensis Bailey. Missouri River Beaver.

1919. *Castor canadensis missouriensis* Bailey, Jour. Mammalogy, Vol 1, p. 32.

TYPE LOCALITY.—Apple Creek, seven miles east of Bismarck, Burleigh County, North Dakota.

Occurrence.—The beaver have staged a successful comeback, especially along the Kansas river and its tributaries. The Kansas State Game and Fish Commission have trapped many of them for their pelts in the last four years. It was reported that the plan was to take a thousand beaver during the winter of 1942-43. The

exact number of beaver taken is unknown at this writing. Some biologists think that live-trapping should be practiced, and the beaver thus captured used for restocking other streams in the State and surrounding areas where beaver are now extinct.

Family CRICETIDAE. New World Mice and Rats.

Onychomys leucogaster articeps Rhoads. New Mexico Grasshopper Mouse.

1898. *Onychomys arcticeps* Rhoads, Proc. Acad. Nat. Sci. Philadelphia, p. 194.

TYPE LOCALITY.—Clapham, Union County, New Mexico.

Occurrence.—This mouse inhabits the short grass areas of western Kansas.

Onychomys leucogaster breviauritus Hollister. Oklahoma Grasshopper Mouse.

1913. *Onychomys leucogater breviauritus* Hollister, Proc. Biol. Soc. Wash., Vol. 26, p. 216.

TYPE LOCALITY.—Fort Reno, Canadian County, Oklahoma.

Occurrence.—The Oklahoma Grasshopper Mouse occurs east of the range of the New Mexico Grasshopper Mouse, extending eastward to the Flint Hills. Joe A. Tihen collected seven specimens in Harper County, in 1938 and '39. George C. Rinker collected two in Ellsworth County, August 27, 1941. The range of this mouse is poorly known in Kansas, since the mammals of the central part of the state have not been carefully studied.

Reithrodontomys albescens albescens Cary. Pallid Harvest Mouse.

1903. *Reithrodontomys albescens* Cary, Proc. Biol Soc. Wash., Vol. 16, p 53.

TYPE LOCALITY.—Eighteen miles northwest of Kennedy, Cherry County, Nebraska.

Occurrence.—The Pallid Harvest Mouse ranges throughout the western third of Kansas.

Reithrodontomys albescens griseus Bailey. Little Gray Harvest Mouse.

1905. *Reithrodontomys griseus* Bailey, N. Amer. Fauna, No. 25, p. 106.

TYPE LOCALITY.—San Antonio, Bexar County, Texas.

Occurrence.—Common throughout the State in grass land except the western one-third and the extreme southeastern corner. See Hibbard, (1938, pp. 175-176) concerning habits of this mouse in Kansas.

Reithrodontomys megalotis aztecus Allen. Aztec Harvest Mouse.

1893 *Reithrodontomys aztecus* Allen, Bull. Amer. Mus. Nat. Hist., Vol. 5, p. 79

TYPE LOCALITY.—LaPlata, San Juan County, New Mexico.

Occurrence.—This harvest mouse is found in the moist areas of extreme southwestern Kansas. Besides the specimens reported by Hill and Hibbard (1943, pp. 22-25), George C. Rinker and Henry H. Hildebrand collected additional specimens from a bog area north of Fowler, Kansas, near Crooked creek, as well as two specimens from a timbered area along Crooked creek in Ford County, Kansas, in the summer of 1942.

Reithrodontomys megalotis dychei Allen. Prairie Harvest Mouse.

1895. *Reithrodontomys dychei* Allen, Bull Amer. Mus. Nat. Hist. Vol. 7, p. 120.

TYPE LOCALITY.—Lawrence, Douglas County, Kansas.

Occurrence.—The Prairie Harvest Mouse to date is known only from the Kansas river and its tributaries, that is, the north half of Kansas. It inhabits the valleys and bottom lands along wooded fence rows, and weed patches along the edge of the timber.

Reithrodontomys fluvescens aurantius Allen. Golden Harvest Mouse.

1895. *Reithrodontomys mexicanus aurantius* Allen, Bull Amer. Mus. Nat. Hist, Vol. 7, p. 137.

TYPE LOCALITY.—Lafayette, Lafayette Parish, Louisiana.

Occurrence.—The Golden Harvest Mouse occurs in the extreme southeastern corner of Kansas. Besides the two specimens previously reported (Hibbard, 1938) from Cherokee County, James M. Sprague collected a specimen July 28, 1938 at the southwestern edge of Cedar Vale, Chautauqua County, Kansas.

Peromyscus maniculatus bairdii (Hoy and Kennicott). Baird's White-footed Mouse.

1857. *Mus bairdii* Hoy and Kennicott, in Kennicott, Agricultural Report, U. S. Patent Office, 1856, p. 92.

TYPE LOCALITY.—Bloomington, McLeon County, Illinois.

Occurrence.—This mouse is common throughout the eastern half of Kansas and intergrades with *P. maniculatus nebrascensis* (Coues) to the west. It is confined chiefly to the grasslands and uplands. Habitat in general the same as that of *Reithrodontomys albescens.*

Peromyscus maniculatus nebrascensis (Coues). Nebraska Deer Mouse.

1877. *Hesperomys sonoriensis* var. *nebrascensis* Coues, Monogr. N. Amer. Rodentia, p. 79.

TYPE LOCALITY.—Deer Creek, western Nebraska.

Occurrence.—The upland deer mouse of western Kansas is considered to be this form. Considerable variation occurs in the population of the southwestern part of the State in comparison with those of northwestern Kansas. In Barber, Comanche, Kiowa, Clark

and Meade Counties two color phases exist, a rufus phase and a paler phase typical of the northern *nebrascensis.*

Peromyscus leucopus aridulus Osgood. Badlands White-footed Mouse.

1909. *Peromyscus leucopus aridulus* Osgood, N. Amer. Fauna, No. 28, p. 122.

TYPE LOCALITY.—Fort Custer, Yellowstone County, Montana.

Occurrence.—These large white-footed mice are found along the timbered streams of the western part of the State. Their distribution is discontinuous due to the isolated timbered areas along our western streams. Their range to the east meets that of the northern deer mouse.

Peromyscus leucopus noveboracensis (Fischer). Northern Wood Mouse.

1829. [*Mus sylvaticus*] δ *noveboracensis* Fischer, Synopsis Mammalium, p. 318.

TYPE LOCALITY.—New York.

Occurrence.—This mouse occurs throughout eastern Kansas in the wooded areas and its range extends westward up the rivers and their tributaries to meet that of *P l. aridulus.*

Peromyscus leucopus tornillo Mearns. Tornillo Deer Mouse.

1896. *Peromyscus tornillo* Mearns, Preliminary diagnosis of new mammals from the Mexican border of the United States, p. 3.

TYPE LOCALITY.—Rio Grande, about six miles above El Paso, El Paso County, Texas.

Occurrence.—Known only from the extreme southwestern corner of Kansas. It has been found to occur along rocky ledges capping the canyon walls.

Peromyscus boylii attwateri Allen. Attwater's Deer Mouse.

1895. *Peromyscus attwateri* Allen, Bull Amer. Mus. Nat. Hist., Vol. 7, p. 330.

TYPE LOCALITY.—Turtle creek, Kerr County, Texas.

Occurrence.—This mouse inhabits the brushy rock ledges of extreme southeastern Kansas.

Oryzomys palustris texensis Allen. Texas Rice Rat.

1894. *Oryzomys palustris texensis* Allen, Bull Amer. Mus. Nat. Hist., Vol. 6, p. 177.

TYPE LOCALITY.—Rockport, Aransas County, Texas.

Occurrence.—The only record to date of the Texas Rice Rat from Kansas is the specimen taken by Capt. B. F. Goss at Neosho Falls, Woodson County. Intensive collecting has never been done along the Neosho river and the extreme southeastern corner of Kansas remains unstudied.

Sigmodon hispidus texianus (Audubon and Bachman). Texas Cotton Rat.

1853. *Arvicola texiana* Audubon and Bachman, Quadr. N. Amer. Vol. 3, p. 229.

TYPE LOCALITY.—Brazos river, Texas.

Occurrence.—In the past ten years the Texas Cotton Rat has pushed northward throughout Kansas. In 1933 the most northeastern record of the cotton rat was Greenwood County, Kansas. During the next 10 years, the population increased tremendously. In the spring of 1941 the first specimens were taken in Douglas County, seven miles south and west of Lawrence (see Rinker 1942, p. 439). By the fall of 1942, the cotton rat was abundant in the fields and fence rows about Lawrence. That winter Rinker took them north of Lawrence at Lake View, on the south banks of the Kansas river. The population was so numerous in Douglas County that they were common on the campus of the University, and one wandered into the basement of the museum in the fall of 1942. At the present time (April, 1944) they are abundant around Lawrence. In Meade County, in the summer of 1942, *Sigmodon* overran the bottom land of Crooked creek and pushed out of the valleys onto the High Plains, where they were abundant in the upland wheat fields and common along fence rows of the upland short grass pastures. How far north they have moved in central and western Kansas is unknown, as there has been no opportunity to make a study of the problem. It will be interesting to note whether or not they can maintain themselves in this newly invaded territory. This northern extension of range is possibly correlated with the drought and the change in abundance of certain food plants.*

Neotoma floridana baileyi Merriam. Bailey's Wood Rat.

1894. *Neotoma baileyi* Merriam, Proc. Biol. Soc. Wash. Vol. 9, p. 123
1905. *Neotoma floridana baileyi* Bailey, N. Amer Fauna, No. 25, p. 109.

TYPE LOCALITY.—Valentine, Cherry County, Nebraska.

Occurrence.—Known from the wooded hillsides along the Republican river and its tributaries of northwestern Kansas.

Neotoma floridana campestris Allen. Kansas Wood Rat.

1894. *Neotoma campestris* Allen, Bull. Amer. Mus. Nat Hist. Vol. 6, p 322.
1914. *Neotoma floridana campestris* R. Kellogg, Kansas Univ. Mus. Nat. Hist. Publ. 1, Zool. Ser., Vol. 1, No. 1, p. 5.

TYPE LOCALITY.—Pendennis, Lane County, Kansas.

Occurrence.—Known only from the chalk bluffs along the Smoky Hill river and its tributaries in western Kansas.

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*Dr. G. C. Rinker spent from July 19 to July 30, 1944 trapping in the areas of Meade County that were known to be heavily populated by Cotton Rats for the past six years. No specimens were caught or seen during that time. In three weeks of intensive field work in the county I have seen only one specimen. Signs of the rate are rare.

Neotoma floridana osagensis Blair. Osage Plains Wood Rat.

1939. *Neotoma floridana osagensis* Blair, Occas. Pap. Mus. Zool. Univ. Mich. No. 403, p. 5.

TYPE LOCALITY.—Okesa, Osage County, Oklahoma.

Occurrence.—The Osage Plains Wood Rat, better known as the pack rat, occurs throughout eastern Kansas. How far its range extends westward up the Kansas river is unknown.

Neotoma micropus micropus Baird. Baird's Wood Rat.

1855. *Neotoma micropus* Baird, Proc. Acad. Nat. Sci. Philadelphia, p. 333.

TYPE LOCALITY.—Charco Escondido, Tamaulipas, Mexico.

Occurrence.—This rat is common in the canyons of Barber and Comanche counties. It builds elaborate nests in Kiowa County among the drift and hollow trees along the streams, and is found westward in Clark County along the bluffs and canyons.

Neotoma micropus canescens Allen. Hoary Pack Rat.

1891. *Neotoma micropus canescens* Allen, Bull. Amer. Mus. Nat. Hist., Vol. 3, p. 285.

TYPE LOCALITY.—North Beaver creek, Beaver County, Oklahoma.

Occurrence.—The Hoary Pack Rat is common around the bluffs and in old badger dens in Meade, Seward, Stevens and Morton Counties. Its northward limit of range is not known. Black (1937, p. 199), states that, "They live, in our section, almost entirely in caves, * * * * . I have seen rubbish heaps in caves, but I have also found one extremely compact nest on a ledge in a cave, completely exposed and very birdlike, which was occupied by an adult female, nursing young." This pack rat has never been found in the cave region of Kansas. *Neotoma micropus micropus* does occur in the cave region of Kansas and lives in the caves, but the nesting habit reported by Black has never been observed for this species. Black was never west of the Flint Hill region in Kansas or in the caves or cave area during the period of his study of Kansas mammals. It appears that Black confused his field notes on *Neotoma floridana attwateri* (Mearns) from northwestern Arkansas with those pertaining to *Neotoma micropus canescens.* (See Black, 1936, p. 33).

Synaptomys cooperi gossii (Coues). Goss' Lemming Mouse.

1877. *Arvicola (Synaptomys) gossii* Coues, Monogr. N. Amer. Rodentia, p. 235.

TYPE LOCALITY.—Neosho Falls, Woodson County, Kansas.

Occurrence.—Known only from Anderson, Douglas, Stafford and Woodson counties, Kansas.

Synaptomys cooperi paludis Hibbard and Rinker. Bog Lemming Mouse.

1942. *Synaptomys cooperi paludis* Hibbard and Rinker, Univ. Kansas Sci. Bull. Vol. 28, pt. 1, No. 2, p 26

TYPE LOCALITY.—Bog area surrounding broader Pond No. 1, Meade County State Park, 14 miles southwest of Meade, Meade County, Kansas.

Occurrence.—Known only from the bog area of Meade County State Park.

Microtus ochrogaster ochrogaster (Wagner). Prairie Meadow Mouse.

1842. *Hypudaeus ochrogaster* Wagner, Schreber's Säugethiere, Suppl., Vol. 3, p. 592.

TYPE LOCALITY.—New Harmony, Posey County, Indiana. (See Bole and Moulthrop, 1942, p. 157).

Occurrence.—The vole of eastern Kansas is referred to this subspecies. It was being studied by George C. Rinker at the time he was called to military service. The vole studied by Edith Beach and reported as *Microtus pennsylvanicus* (see Beach, 1931, p. 125) belonged to the subgenus *Pedomys* and not the subgenus *Microtus.* Miss Beach has informed me that she trapped the specimens just southwest of the University of Kansas campus (Douglas County) in a bluegrass patch where we have taken many specimens of *Microtus ochrogaster.* Living specimens of *Microtus pennsylvanicus* have never been taken in Kansas.

Microtus ochrogaster haydenii (Baird). Hayden's Vole.

1857. *Arvicola (Pedomys) haydenii* Baird, Mamm. N. Amer., p. 543.

TYPE LOCALTY.—Fort Pierre, Stanley County, South Dakota.

Occurrence.—This vole is found in northwestern Kansas.

Microtus ochrogaster taylori Hibbard and Rinker. Taylor's Vole.

1943. *Microtus ochrogastor taylori* Hibbard and Rinker, Univ. Kansas Sci. Bull. Vol. 29, pt. 2, No. 4, p. 256.

TYPE LOCALITY.—H. H. Hildebrand farm, 1½ miles north of Fowler, Meade County, Kansas.

Occurrence.—This vole occurs in southwestern Kansas. The extent of its range is unknown. (See Hibbard and Rinker, 1943.)

Pitymys nemoralis (Bailey). Woodland Pine Mouse.

1898. *Microtus pinetorum nemoralis* Bailey, Proc. Biol. Soc. Wash., Vol. 12, p. 89.

TYPE LOCALITY.—Stilwell, Adair County, Oklahoma.

Occurrence.—The Woodland Pine Mouse is confined to the wooded areas of eastern Kansas. Its westward extension along streams is unknown.

Ondatra zibethicus zibethicus (Linnaeus). Common Muskrat.

1766. [*Castor*] *zibethicus* Linnaeus, Syst. Nat., ed. 12, Vol. 1, p. 79.
1940. *Ondatra zibethicus zibethicus* Davis and Lowery, Jour. Mammalogy, Vol. 21, No. 2, p. 212.

TYPE LOCALITY.—Eastern Canada.

Occurrence.—The Common Muskrat is found in the extreme southeastern corner of Kansas.

Ondatra zibethicus cinnamominus (Hollister). Great Plains Muskrat.

1910. *Fiber zibethicus cinnamoninus* Hollister, Proc. Biol. Soc. Wash., Vol. 23, p. 125.

TYPE LOCALITY.—Wakeeney, Trego County, Kansas.

Occurrence.—This muskrat is found throughout the entire State along the rivers and streams except in the southeastern corner.

Family MURIDAE. Introduced (Old World) Rats and Mice.

Rattus rattus rattus (Linnaeus). Black Rat.

1758. [*Mus*] *rattus* Linnaeus, Syst. Nat., ed. 10, Vol. 1, p. 61.

TYPE LOCALITY.—Upsala, Sweden.

Occurrence.—The Black Rat was once common throughout eastern United States, but it has been replaced in Kansas by the House Rat, *Rattus norvegicus.* Introduced into North America.

Rattus norvegicus norvegicus (Berkenhout). Norway Rat or House Rat.

1769. *Mus norvegicus* Berkenhout, Outl. Nat. Hist. Great Britain, Vol. 1, p. 5. Norway (*fide* Allen, Glover M., 1939, p. 413).
1777. *Mus norvegicus* Erxleben, Syst. Regn. Anim. Vol. 1, p. 381.

TYPE LOCALITY.—Norway.

Occurrence.—The House Rat or Barn Rat is abundant throughout Kansas.

Mus musculus musculus Linnaeus. House-mouse.

1758. [*Mus*] *musculus* Linnaeus, Syst. Nat., ed. 10, Vol. 1, p. 62.

TYPE LOCALITY.—Upsala, Sweden.

Occurrence.—Common throughout the State, introduced in North America.

Family ZAPODIDAE. Jumping Mice.

Zapus hudsonius campestris Preble. Prairie Jumping-mouse.

1899. *Zapus hudsonius compestris* Preble, North Amer. Fauna, No. 15, p. 20.

TYPE LOCALITY.—Bear Lodge mountains, Crook County, Wyoming.

Occurrence.—The Jumping-Mouse is rare in Kansas. It is known chiefly from the eastern part of the State.

Family ERETHIZONTIDAE. American Porcupines.

Erethizon epixanthum bruneri Swenk. Nebraska Yellow-haired Porcupine.

1916. *Erethizon epixanthum bruneri* Swenk, Univ. Studies Nebr., Vol. 16, p. 117.

TYPE LOCALITY.—Three miles east of Mitchell, Scottsbluff County, Nebraska.

Occurrence.—A few porcupines remain in northwestern Kansas. They are becoming rare. A specimen was taken by Joe Tihen in Kingman County, September 20, 1934. A porcupine was killed by my grandfather, Edward A. Hibbard, in the late '70's, along the Verdigris river southwest of Toronto, in Woodson County. The porcupines found along the streams of eastern Kansas at the time of early settlement probably belonged to an eastern race.

Order LAGOMORPHA

Family LEPORIDAE. Rabbits.

Lepus townsendii campanius Hollister. White-tailed Jack Rabbit.

1915. *Lepus townsendii campanius* Hollister, Proc. Biol. Soc. Wash., Vol. 28, p. 70.

TYPE LOCALITY.—Plains of the Saskatchewan, Canada (probably near Carlton House).

Occurrence.—These rabbits are becoming rare in Kansas. The "Old Timers" say they were common in the hill country of Meade County in the early days, but were soon killed off. They have not been seen there for 40 years.

For the present distribution of this rabbit in Kansas, see Brown (1940, pp. 385-389). Brown's paper is a correction to the one published by Carter (1939). Carter gathered his data by questionnaires sent out over the State, and he was unable to evaluate the data, since he was not familiar with the range of the rabbit in Kansas. I personally investigated the status of the white-tailed jack in a number of the counties, especially Harper County, after Carter's paper was presented at the Kansas Academy of Science. I found that the people thought that his reference to the White-tail Jack Rabbit meant the Cottontail, since they had never seen nor heard of but two rabbits, the Jack Rabbit (the Black-tail or Blackeared) and the Cottontail (a rabbit with a white tail). Carter's data is of little value.

Lepus californicus melanotis Mearns. Black-eared Jack Rabbit.

1890. *Lepus melanotis* Mearns, Bull. Amer. Mus. Nat. Hist., Vol. 2, p. 297.

TYPE LOCALITY.—Independence, Montgomery County, Kansas.

Occurrence.—The Black-eared Jack Rabbit is common throughout the State except in the extreme southeastern and northeastern corners.

Sylvilagus floridanus alacer (Bangs). Oklahoma Cottontail.

1896. *Lepus sylvaticus alacer* Bangs, Proc. Biol. Soc. Wash., Vol. 10, p. 136.

TYPE LOCALITY.—Stilwell, Boston mountains, Adair County, Oklahoma.

Occurrence.—The Oklahoma Cottontail is common in south-central Kansas south of the Arkansas river, and it extends eastward to Missouri and north into Greenwood County.

Sylvilagus floridanus mearnsii (Allen). Mearn's Cottontail.

1894. *Lepus sylvaticus mearnsii* Allen, Bull. Amer. Mus. Nat. Hist., Vol. 6, p. 171.

TYPE LOCALITY.—Fort Snelling, Hennepin County, Minnesota.

Occurrence.—Mearn's Cottontail occurs throughout northeastern Kansas, and as far south as northern Greenwood County. Its westward limit of range in the State is unknown.

Sylvilagus floridanus llanensis Blair. Staked Plains Cottontail.

1938. *Sylvilagus floridanus llanensis* Blair, Occas. Pap. Mus. Zool. Univ. Mich. No. 380, p. 1.

TYPE LOCALITY.—Old "F" Ranch headquarters, Quitaque, Briscoe County, Texas.

Occurrence.—The Staked Plains Cottontail occurs along the lower valley of Crooked creek. How far westward it extends along the valley of the Cimarron river is unknown.

Sylvilagus floridanus similis Nelson. Nebraska Cottontail.

1907. *Sylvilagus floridanus similis* Nelson, Proc. Biol. Soc. Wash., Vol. 20, p. 82.

TYPE LOCALITY.—Valentine, Cherry County, Nebraska.

Occurrence.—The Nebraska Cottontail occurs in northwestern Kansas and ranges east and south to meet the range of the other subspecies of *S. floridanus* occurring in Kansas.

Sylvilagus audubonii baileyi (Merriam). Wyoming Cottontail.

1897. *Lepus baileyi* Merriam, Proc. Biol. Soc. Wash., Vol. 11, p. 148.

TYPE LOCALITY.—Spring creek, east side of Bighorn Basin, Bighorn County, Wyoming.

Occurrence.—The Wyoming Cottontail occurs in northwestern Kansas, living on the upland and around the bluffs, while the Nebraska Cottontail lives in the valleys and lowlands. Its eastward and southern range in Kansas is unknown.

Sylvilagus audubonii neomexicanus Nelson. New Mexico Cottontail.

1907. *Sylvilagus auduboni neomexicanus* Nelson. Proc. Biol. Soc. Wash., Vol. 20, p. 83.

TYPE LOCALITY.—Fort Sumner, Guadalupe County, New Mexico.

Occurrence.—The New Mexico Cottontail is found in the extreme southwestern part of Kansas and has been taken as far east as Clark County. It occurs on the upland and around bluffs. One of its favorite haunts are prairie dog towns.

Sylvilagus aquaticus aquaticus (Bachman.) Swamp-rabbit.

1837. *Lepus aquaticus* Bachman, Jour. Acad. Nat. Sci. Philadelphia, Vol. 7, p. 319.

TYPE LOCALITY.—Western Alabama.

Occurrence.—The Swamp-rabbit is common in southeastern Kansas along the lowlands of the Neosho river. How far it extends up the river in Kansas is unknown.

Order ARTIODACTYLA. Even-toed Ungulata.

Family CERVIDAE. Deer.

Cervus canadensis canadensis Erxleben. Elk or Wapiti.

1777. [*Cervus elaphus*] *canadensis* Erxleben, Syst. Regni Anim., Vol. 1, p. 305.

TYPE LOCALITY.—Eastern Canada.

Occurrence.—The Elk was once abundant in Kansas, but is now extinct.

Odocoileus hemionus hemionus (Rafinesque). Mule-deer.

1817. *Cervus hemionus* Refinesque, American Monthly Magazine, Vol. 1, p. 436 (*fide* Miller, 1924, p. 485).

TYPE LOCALITY.—Sioux river, South Dakota.

Occurrence.—This deer was once common in Kansas, but is now extinct in the State.

Odocoileus virginianus macrourus (Rafinesque). Plains White-tailed deer.

1817. *Cervus* (misspelled *Corvus*) *macrourus* Rafinesque, American Monthly Magazine, Vol. 1, p. 436, (*fide* Miller, 1924, p. 489).

TYPE LOCALITY.—Plains of Kansas river, upper Mississippi Valley.

Occurrence.—This deer was once common in Kansas, but it is now extinct. It should be reintroduced into eastern Kansas, where there is still abundant range in the timbered areas.

Family ANTILOCAPRIDAE. Pronghorns.

Antilocapra americana americana (Ord). American Antelope.

1815. *Antilope americana* Ord, Guthrie's Geography, 2nd Amer. ed., Vol. 2, p. 292.

TYPE LOCALITY.—"Plains and highlands of the Missouri."

Occurrence.—The antelope was the last of our larger game mam-

mals to be killed off in the State. With the cooperation of our ranchmen and citizens, antelope could be reestablished in the grasslands of western Kansas.

Family Bovidae.

Bison bison bison (Linnaeus). Plains Bison.

1758. [*Bos*] *bison* Linnaeus, Syst. Nat., ed. 10, Vol. 1, p. 72.

Type Locality.—Mexico.

Occurrence.—Once common throughout Kansas but now extinct.

Order Endentata.

Family Dasypodidae. Armadillos.

Dasypus novemcinctus texanus (Bailey). Nine-banded Armadillo.

1905. *Tatu novemcinctum texanum* Bailey, N. Amer. Fauna, No. 25, p. 52.

Type Locality.—Brownsville, Cameron County, Texas.

Occurrence.—A few years ago an Armadillo was found living in a den in Chase County near Strong, Kansas. September 9, 1942, Mr. B. F. Hardesty killed an armadillo on his farm 4½ miles northwest of Caldwell, Sumner County, Kansas. This specimen was sent to the University of Kansas Museum by Mr. Virgil Mossman of the Caldwell Public Schools. Whether these specimens were "escapes" is not known, though it is known that the armadillo has extended its range northward in Oklahoma. The specimen from Sumner County may have been an individual that had moved northward from Oklahoma.

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A Correlation of Some Terms Used in Theoretical Inorganic and Organic Chemistry

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On the momentous occasion, in 1834, of the reading of Dumas' paper on substitution before the Academy of Sciences at Paris, the opening guns were fired in a long and bitter struggle between Berzelius, on the one hand, and the French school, headed by Laurent and Dumas, on the other. This extended argument marked the parting of the ways for inorganic and organic chemistry. Inorganic chemistry continued to use and to develop the electrochemical theory; organic chemists, however, abandoned the electrochemical theory almost entirely and contented themselves with the development and application of structural theory.

There is admittedly some basis for this divorce of inorganic and organic chemistry. Whereas a great many of the reactions encountered in inorganic chemistry are ionic in character, relatively few organic molecules are ionized in solution. In organic reactions ions are postulated as existing, if at all, only as unstable and transient intermediates. With the development of the modern electronic theory, however, and its application to organic chemistry, it has become apparent that this separation is more superficial than real. Although organic molecules are not ordinarily ionized, nevertheless they are thought to be activated by the development, either permanently or incipiently, of positive and negative centers within the molecule, and a vast majority of organic reactions are initiated by the attack of the positive center of one molecule upon the negative center of another. Consequently, similar electrochemical concepts actually underlie both theoretical inorganic and organic chemistry.

As a result of the separate development of these two divisions, however, the science has become cluttered with a dual system of nomenclature so that two completely unrelated, if not conflicting, sets of terms are often employed to describe similar or identical theoretical concepts or principles. The result is that the student of organic chemistry is compelled to learn a completely new and unfamiliar set of names for an old and familiar set of ideas. It is the purpose of this paper to correlate certain similar concepts of in-

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organic and organic chemistry and to propose terms for these concepts which suggest their correlation.

According to the most widely accepted theories of organic chemistry, organic molecules are activated as a result of the development of permanent or temporary positive and negative centers within the molecule. Two general types of electron displacement are responsible for the development of these centers, the so-called inductive, or I effect and the tautomeric, or T effect*. The general inductive or I effect is further subdivided into the static inductive, the I_s, effect, and the dynamic inductomeric, or I_d, effect.

The permanent inductive, or I_s, effect is described as electron displacement arising from the unequal sharing of the electron pair of a single covalent bond by the two atoms or groups which it binds together. In general, if two different atoms or groups are joined by a single covalent bond, the pair of electrons constituting this bond will be displaced toward the more electronegative atom or group. The term electronegativity is employed in the ordinary sense to mean the power of an atom or group to attract electrons to itself. Thus, in the simple case of the HCl molecule, the bonding electron pair is displaced toward the more electronegative chlorine atom, leaving the hydrogen atom a center of positive charge and the chlorine atom a center of negative charge:

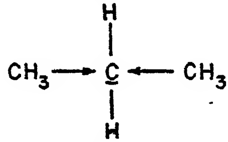
$$\underset{+}{\mathrm{H}} \longrightarrow \underset{-}{\mathrm{Cl}}$$

This effect is designated in organic chemistry as the static inductive effect but is, in reality, nothing more than polarization.

The temporary inductomeric, or I_d, effect is defined as the incipient displacement of the electron pair of a single covalent bond called into play by a change in the electrostatic environment such as the approach of a polar molecule. Such an effect must be operative in the chlorination of propane, for example, in which the major product is secondary chloropropane although there are six primary hydrogen atoms to two secondary ones, and, despite the fact that there is virtually no permanent polarization in the propane molecule. The most reasonable explanation is the assumption that the field of the attacking reagent induces in the molecule a polarity

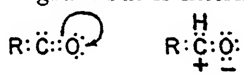
*See for example, Watson, *Modern Theories of Organic Chemistry,* Oxford University Press, 1941, pp. 82-105 for a more extended discussion of these effects.

which results in the production of a relatively negative center at the secondary carbon.



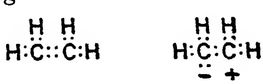
This effect, therefore, is nothing more than polarizability, or, to be more specific, single-bond polarizability.

The tautomeric, or T, effect of organic chemistry is a term applied to electron displacements associated with multiple bonds and unshared electron pairs. The T effect is further subdivided, according to its permanence, into the mesomeric, or M, and the electromeric, or E, effects. The mesomeric, or M, effect is a permanent displacement associated with multiple bonds and unshared electron pairs. Such an effect exists, for example, in an aldehyde system, in which the true electron configuration cannot be represented by a single electron diagram but is intermediate between the two structures shown:



The carbon atom is thus represented as a permanent positive center and the oxygen atom as a permanent negative center. But this effect is an example of the well known concept of polarization in inorganic chemistry which is called resonance.

When the tautomeric effect is temporarily evoked by an electric field external to the molecule under consideration, it is designated as the electromeric, or E, effect. Such an effect is postulated to account for the reaction of an olefin such as ethylene with a polar molecule such as hydrogen chloride:



Positive and negative charges, respectively, are thus temporarily induced on the two carbon atoms. This effect is, again, merely a polarizability, or, more specifically, a multiple bond polarizability. These correlations are summarized as follows:

Electron Displacements

	Polarization		*Polarizability*	
Inductive	Polarization	(P)	Single bond Polarizability	(P_s)
	Inductive	(I_s)	Inductomeric	(I_d)
Tautomeric	Resonance	(R)	Multiple bond Polarizability	(P_m)
	Mesomeric	(M)	Electromeric	(E)

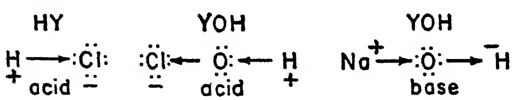
As indicated in the above discussion, the electron displacements postulated to explain the behavior of organic molecules result in the development of centers of low electron density and centers of high electron density. In the usual terminology, these are referred to as electrophilic and nucleophilic centers, respectively. In keeping with designations familiarly employed in inorganic chemistry, we recommend the substitution of the terms cationic and anionic centers:

	Organic Designation	*Proposed Designation*
Positive center (+)	Electrophilic center	Cationic center
Negative center (—)	Nucleophilic center	Anionic center

Reactive molecules always possess both cationic and anionic centers, but as a general rule one center is clearly more reactive than the other, and the molecule as a whole may be designated as predominantly cationic or anionic. Bimolecular reactions in organic chemistry are thought to be initiated by the attack of the reactive cationic center of one molecule upon the reactive anionic center of a second.

It is interesting to correlate the above discussion with our familiar concepts of acids and bases—those of Arrhenius, of Brönsted and of Lewis. According to the Arrhenius[1] definition, an acid is a substance which affords hydrogen ions in aqueous solution and a base is a substance which affords hydroxide ions in solution. Although we are now putting words into the mouth of Arrhenius, it is obvious that only substances of high cationic character which is centered at a hydrogen atom, would be capable of dissociation to give hydrogen ions in water solution. In other words, an acid is a substance containing highly reactive cationic hydrogen. Such an hydrogen atom is one which is bound to an atom or group of exceedingly high electronegativity. In general, HY or YOH is an acid if Y is strongly electronegative; if, on the other hand, Y is very weakly electronegative, then YOH is an Arrhenius base, and it will dissociate in water solution to give OH^- ions.

For example:



It was Dr. E. C. Franklin, formerly of the University of Kansas, who apparently was the first to recognize that the classical

[1]Arrhenius, Z.physik.Chem. I, 631-648 (1887).

Arrhenius definitions of acids and bases were without meaning in non-aqueous solvents and were therefore not sufficiently broad to be truly fundamental. This limitation is overcome in the broader Brönsted-Lowry[2] concept, which is valid also when applied to common non-aqueous solutions. From the point of view of the Brönsted idea, an acid is defined as a proton donor, a substance capable of giving up protons. The false assumption of the followers of Arrhenius that free protons exist in a solution of an acid is avoided; an acid does not release a proton, as such but rather transfers it to a base, a substance capable of forming covalent links with protons. Fundamentally, a Brönsted acid is no different from an Arrhenius acid; both are substances possessing cationic hydrogen. The Brönsted term is much more inclusive, however, as many substances contain a hydrogen atom which, although not sufficiently cationic to be transferred as a proton to water, may yet be sufficiently cationic to be transferred to a stronger base such as OH^-, $C_2H_5O^-$, or NH_2^-. The Brönsted definition of a base is exceedingly broad; any substance which possesses a reactive anionic center is potentially a base. It is interesting to note that, under this concept, not only is HY an acid if Y is strongly electronegative but it is likewise a base if Y is weakly electronegative. Thus, sodium hydride, NaH, contains H^- ions which react with water or other proton donors to produce hydrogen:

$$\text{H}:^{-} + \text{H}:\text{X} \xrightarrow{\text{Na}^{+}\ :\text{H}^{-}} \text{H}:\text{H} + :\text{X}^{-}$$

The definition of the term "base" as suggested by G. N. Lewis is essentially identical with that of Brönsted. According to Lewis[3], a base is a "substance which has a lone pair of electrons which may be used to complete the stable group of another atom"; in other words, a base is a reactive anionic center. A Brönsted base exerts its basic function when the anionic center accepts a proton from an acid; but a proton is by no means the only substance which can accept the lone electron pair of an anionic center, and Lewis doubts the wisdom of restricting the definition of an acid to a reactive cationic center in which the cationic activity is localized at a hydrogen atom. He suggests, rather, that any substance which can "employ a lone pair of electrons from another molecule in completing the stable group of one of its own atoms" be termed an acid; in other

[2]Brönsted; (a) Rec. P.B., 42, 718 (1923); (b) Chem. Rev., 5, 284 (1928); Lowry, J. Soc. Chem. Ind. 42, 43 (1943).

[3]G. N. Lewis, *Valence and Structure of Atoms and Molecules,* The Chemical Catalog Co. pp. 141-142.

words, *any* substance possessing a reactive cationic center is a potential acid. In the broadest sense of the Lewis concept, all reactions initiated by the attack of a cationic center upon an anionic center are essentially acid-base reactions. This type of behavior includes practically all of the common reactions of organic chemistry.

In order that the common workaday concept of acids and bases be maintained and in order to avoid confusion in terminology, we suggest that the application of the terms "acid, "base", and "neutralization" be limited to the classical Arrhenius sense, and we propose the following Brönsted and Lewis counterparts:

Arrhenius	Acid	Base	Neutralization
Brönsted	Protophobe	Protophile	Protolysis
Lewis	Aniophile	Catiophile	Coordination

Finally, how can the concepts of oxidation and reduction be interpreted in terms of our ideas of cationic and anionic character? The traditional idea of oxidation and reduction as a change in valence number is a useful empirical tool in the writing of formulas and in balancing of equations, but it provides no insight into the actual mechanism of the process. In attempting to clothe the oxidation-reduction process with physical reality, many inorganic chemists have displayed an undue devotion to the electron transfer notion. The electron-transfer concept is, to be sure, valid in certain cases, but in many more cases we regard it as pure hokum. What outright loss of electrons, for example, can be discerned in the oxidation of methane to methyl alcohol, or what gain of electrons in the reduction of carbon dioxide to carbon monoxide?

Although we do not recommend that the following concepts be taught to freshman students, we suggest, for our own intellectual satisfaction, a broader concept of oxidation-reduction which does possess physical significance. Let oxidation be considered as any reaction in which the cationic character of a substance is enhanced; and reduction as any reaction in which the anionic character of a substance is enhanced. Any aniophile, or Lewis acid, is then potentially an oxidizing agent, and any Lewis base, or catiophile, is potentially a reducing agent. In the light of these concepts, the initial stage, at least, of almost all organic reactions is an oxidation-reduction mechanism.

A Suggested Classification of Great Plains Dust Storms

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Despite a general public interest in "dust storms" for more than 3,000 years, there have been surprisingly few scientific investigations in this field. Not even a comprehensive listing of the characteristic phenomena of dust storms has been made and there exists no serious attempt at their classification; and therefore no system of nomenclature. This contribution is made in the hope of providing some kind of framework for wider studies and a better basis for systematic investigations.

Since ancient times and in the literatures of more than thirty nations, we find accounts of those great natural disturbances that so generally and simply have been called "dust storms," or the equivalent in each foreign language. Many of the writings of all those centuries, although interesting, have but little practical or scientific value. Most of them obviously have resulted from interest that was only incidental to other main topics, and were not the products of long-continued, careful and systematic investigation. Probably it is largely on this account that nearly all textbooks dismiss this subject with but brief mention, or omit it completely.

Although these vast colloidal reactions involve physical forces of the first order, and exemplify major-scale processes in chemistry, this field of study, generally, has been overlooked or ignored by the writers in both the fields of physics and chemistry. Strangely, too, textbooks in meteorology and geology also treat this subject as a stepchild. Again the reason probably is to be found in the fact that so few students have had close acquaintance with dust storm phenomena and little or no opportunity to gather original data.

The present interest in beginning a terminology and in making a classification of dust storms and their known causes, had its origin in the writer's long residence in the northern Great Plains as well as the southern and some in the "Dust Bowl" itself. Residence there was accompanied and also was followed by numerous field studies, and by several long series of laboratory experiments. Some of these experiments were upon dusts generally; others upon western aeolian soil deposits as well as upon ancient buried desert materials.

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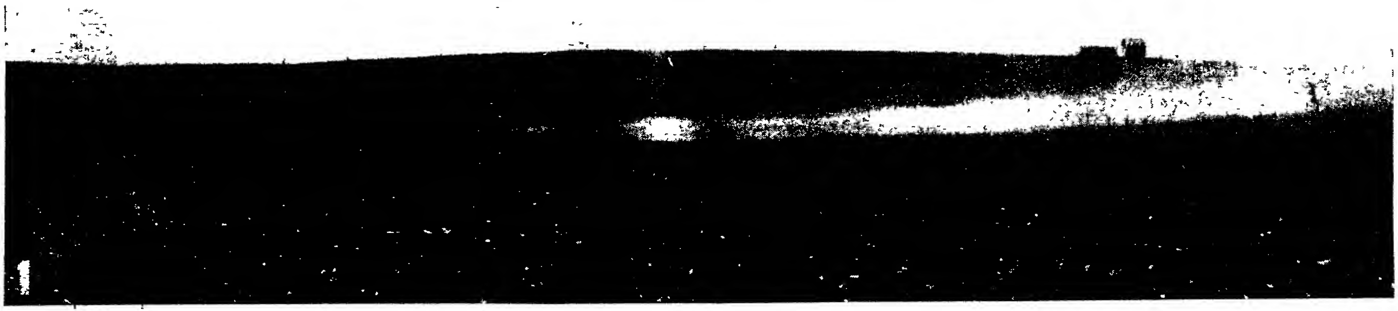

Figure 1.—Class I. Rectilinear Dust Storm; Species I "Sandblow". Only dry soil blows badly. Irrigation definitely helps to prevent this. The photographs reproduced in Figures 1, 2, 3, 4, 6, 7 and 8 have been supplied through the courtesy of the United States Soil Conservation Service, Washington, D. C.

Known Causes of Dust Storms

Prior to 1937, only "drouth" and "high winds" were recognized generally by students as the causes of dust storms. In June of that year announcement was made[1] of a third cause, namely, "exposed soils" as a result of studies carried on by the Soil Conservation Service of the United States Department of Agriculture.

But since some of the characteristic and well-known phenomena of dust storms cannot be accounted for on the basis of these three causes only, a paper[2] prepared the same year, pointed out the probable involvement of other factors also. In particular, attention was called to the common occurrence of a number of electrical phenomena several hours prior to the origin of dust storms of the larger and more violent types which involve whirling or "boiling" movements of the dust particles on a large scale. Such phenomena include "St. Elmo's fires" or bluish discharge lights sometimes seen on trees but usually on wire fences and metal objects; strong shocks often received by persons touching iron implements, fences, etc.; and "burning" of crops at some spots in many fields. The occurrence of such phenomena and the fact that quite commonly they occur ahead of the larger dust storms, as well as afterwards, are well known and widely attested. Too commonly it was merely assumed that they were the *results* of dust storms. In the absence of any systematic and complete gathering of data on atmospheric electricity, by the Weather Bureau since 1888, the fact of "initial electrostatic" forces, as well as post-storm "static," generally had been overlooked. Although its influence has been suspected by Gautier and a few others, none had ever demonstrated its involvement as one of the factors.

In these investigations this involvement has been shown by (a) many field observations, (b) by numerous photographs showing characteristic movements of the dust that were produced at will in the laboratory by electrical forces alone. Photographs also have been taken at many localities showing similar movements of the dust in the natural disturbances. This involvement has also been shown repeatedly by demonstrations. One particular convincing demonstration by the author was that before the Chemistry Section of the Kansas Academy of Science, 1943.

It is worthy of note that in all these demonstrations, use was

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[1]Discussion in the International Dust Storm Symposium. Joint meeting with Geol. Soc. Amer. and Amer. Assn. for Adv. of Science, Denver, Colorado June, 1937.

[2]Keith, B. Ashton "Concerning a Need for Further Investigations on the True Causes of Dust Storms." Bull. Mid-west Acad. Science, Aug 1937, Kansas City Also Abstract to the Dust Storm Congress, Amarillo, Tex., Sept. 1937.

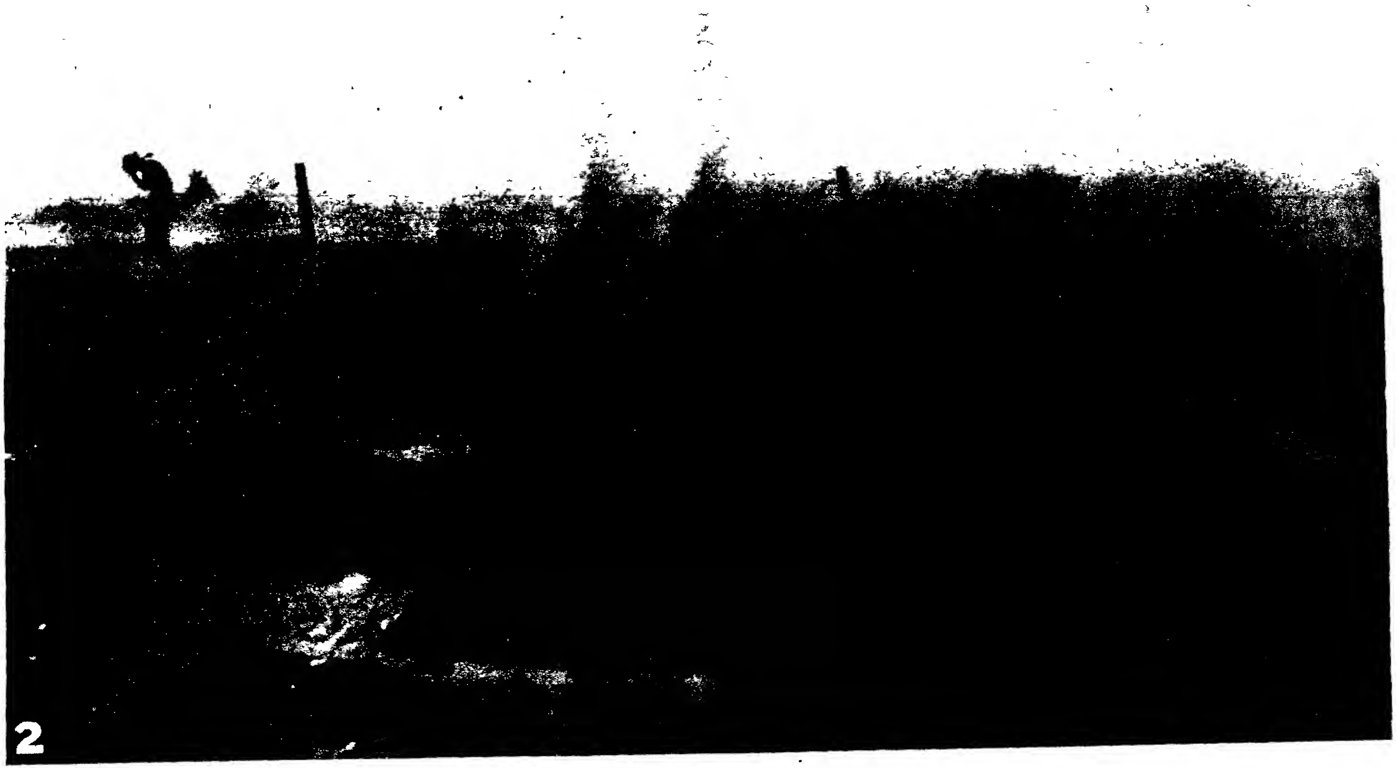

FIGURE 2.—Class I, Species 2, "Straight-blow Duster" or simply "Duster."

made of only one-fourth to one-third the electrostatic field strength that so frequently and so widely on the Great Plains has been observed several hours prior to the origin of most of the larger dust storms, as well as in times of "static storms."

In this connection a description of an actual electrical storm by S. D. Flora[4], Kansas observer for the U. S. Weather Bureau is pertinent:

> An unusually severe electrical storm of the kind described in the Monthly Weather Review of June, 1912, occurred in the three western tiers of Kansas counties on March 23, Easter Sunday.
>
> During this storm windmills, especially steel mills mounted on wooden supports, became so charged with static electricity that any person touching them received a distinct shock, and in some cases the shock was a severe one. The cooperative observer at Tribune, Greely County, reports an instance where sparks 2 or 3 inches long were drawn from a wire running to a windmill.
>
> Telephone and telegraph wires and wire fences also became charged sufficiently to give quite noticeable shocks, and in Scott County, where the disturbance seems to have been most severe, one case is reported where a prairie fire started on the farm of Mr. J. W. Lough, near Scott County, is thought to have originated from electric sparks caused by a break in a wire fence. As numerous instances were reported where distinct sparks were noted on holding the broken ends of fence wires near together, it is altogether possible that dry grass might have been ignited by a similar phenomenon, though it would certainly be a novel way of accounting for a conflagration.
>
> The cooperative observer at Scott City also reports that sparks passed from a person's finger held near a horse's ear and the horse would shake its head as though it felt the contact of the spark.
>
> In Thomas County it was reported that all green vegetation was killed and in Sheridan County the wheat turned brown after the storm.
>
> These electrical phenomena occurred during high southwest to west winds that attended the rapid eastward passage of an area of low pressure central over Denver, Colo., on the morning of the 23rd.
>
> They were generally experienced from early morning until about sunset and during this time the air was filled with dust and was very dry, with no precipitation during the storm.

Many similar statements might also be quoted. Many have described such conditions as occurring immediately prior to some of the dust storms. Such occurrences are so well known and well understood by many Plains people that accurate forecasts of the coming of dust storms are common. These electrical conditions most commonly precede the disturbances that are listed below as Species 5, 6 and 7.

On the Electrostatic Field Strength

The lengths of the sparks, as reported by Flora, are not exaggerated. Similar observations many times have been made by the writer. Dangerous shocks frequently have been reported from touching metal towers or windmills, wire fences, etc. prior to some dust storms as well as afterwards. Production of sparks of such length

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[4] *Climatological Service*, Dist. No. 7, Report for March 1913, p. 5, U. S. Weather Bureau, Washington.

indicates clearly potential "differences" of the order of 30,000 volts per centimeter. (See for example, Glazebrook, *Dictionary of Applied Physics,* London, 1923, vol. 4, p. 607).

Evidences indicating envolvement of even greater electrical forces many times have been recorded. That such conditions more frequently may be expected on the Great Plains than elsewhere in this country, already has been shown[5].

Great increase of the early electrostatic forces during the progress of a dust storm is, of course, to be expected. That this may be due not only to large-scale abrasion, but also possibly to other causes shortly will be shown in another paper. "Static" phenomena, therefore, are more numerous and also stronger as a rule after a large dust storm has passed. Reasons for emphasis of these matters at this point will appear in the summary of the author's experiments since 1939 given below.

1939-41 Experiments—Series I
(Performed at the Institute of Sciences)
Summation

In this series it was learned that carefully weighed amounts of dusts of several kinds were carried away more rapidly in a wind-tunnel when they bear some (small) electrostatic charge. Those experiments were many times repeated, and with almost uniform results.

The slight charge was applied to the dust simply by stirring it with rods that had been rubbed with appropriate materials after the dust had been placed on an insulated plate inside the metal tube that served as a "tunnel". That the tunnel itself was subject to small accumulations of potential differences was indicated by tests with an electroscope.

1942-1943 Experiments—Series II
(At the University of Kansas)

A hand-turned Toepler-Holz electrostatic generator was used to give a small charge to samples of dusts from various parts of the High Plains, particularly from western Kansas and Nebraska and eastern Colorado. Among other things, it was discovered that very considerable amounts of drouth-dried soils of very minute grain size can be lifted into the air by electrostatic forces alone—no wind-currents being used.

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[5]Humphreys, W. J , *Physics of the Air.*

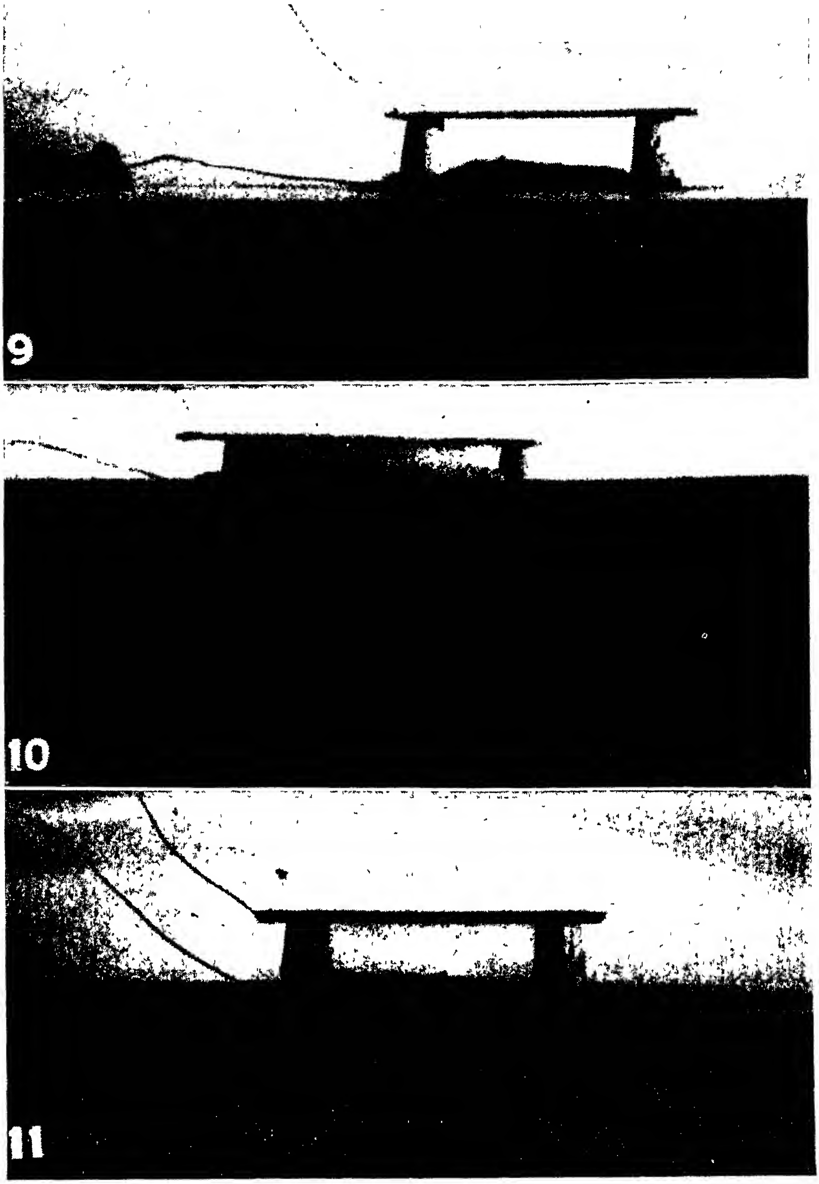

Plate A.—The laboratory production of a dust storm. (Upper) Dry dust loaded on lower plate. The wire leading from the lower plate goes to the negative arm of a Toepler-Halty apparatus; the wire from the upper plate to the positive arm. (Middle) Dust rising from lower plate to upper plate in a field strength of 3500 volts per centimeter; far less than the 30,000 volts per centimeter required to cause the blue lights on clothes lines, fences, etc. Only very fine-grained and very dry soils react in this way. By absorption of moisture in small amounts from the air, these movements greatly are impeded. (Lower) After the "storm". Notice the smoother and lowered dust after only 10 seconds action of the electrostatic forces. No wind currents were employed.

The steps are shown in the accompanying photographs. Small amounts of those soils were placed on a small metal plate laid on a large white paper card. Another metal plate, somewhat wider, was supported above on cork at a distance of 1 cm. from the lower plate. Fine copper wires connected the negative electrode with the lower plate, and the positive electrode with the upper one and 3500 to 5000 stat-volts were then applied for 10 seconds. The removed dusts were carefully weighed, and the amounts per square centimeter were recorded. The general average of a long series of such experiments was computed in terms of *tons of soil per acre per day* that would be removed by electrostatic forces alone. It gave the startling result of 653 tons per acre removed in 24 hours. Thus it has been definitely demonstrated that small electrostatic charge and moderate field strength, can materially assist the winds in lifting very fine-grained soils into the air in times of drouth.

Demonstrations of the rather surprising effects of comparatively small electrostatic forces on very dry and very fine-grained aeolian soils from the principal areas of dust-storm origin on the Plains, make it appear quite probable that "initial" electrostatic influences such as are common in times of static storms should now be considered as a factor in the combinational cause of dust storms of the larger kinds. Obviously such electrical conditions can greatly assist the winds (a) in lifting the finer dust particles into the air and (b) in promoting their wider scattering through the mutually-repelling effects of like charges.

Series III

(Experiments Carried Out in Washington, D. C., 1944)

Clays, silts and other soils gathered in moister, eastern areas and tested in a manner described above showed little or no reaction to electrostatic forces of the same magnitude. This behavior also held true even after these samples had been crushed and ground to small sizes. After moderate heating for several hours, however, these samples were found to react almost as readily to the same electrostatic forces as the wind-blown soils of the High Plains. It was therefore decided to try the effect of reversing the conditions.

Diverse kinds of western soils (some from the Dust Bowl), all of which previously had been found to react readily to electrostatic forces when kept very dry, were placed in small pans and were set inside a large closed box. Two pans of water also were placed inside the box to keep the air saturated with water vapor. After

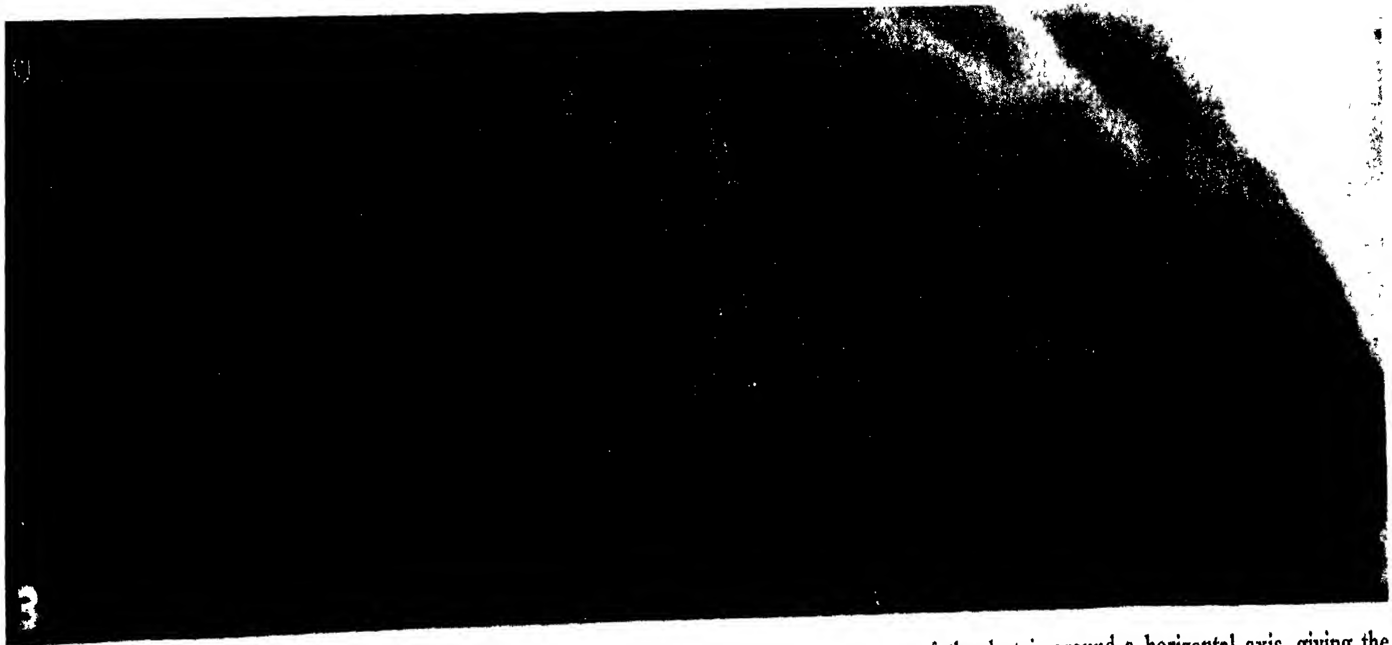

FIGURE 3.—Class II. Rotational Dust Storm, Species 3, "Rolling Duster." (Rotational movement of the dust is around a horizontal axis, giving the appearance of a wall rolling toward the observer.)

leaving these soil samples in the humid air for one week, the moisture-affected dusts were tested for response to electrostatic forces. It was uniformly found that small or no response was shown to electrostatic forces by moisture-affected dusts, even though the same samples react readily when thoroughly dried. In other words, their response to electrical forces may be greatly impeded, or even entirely prevented by promoting increased humidity in the surrounding air.

Present Known Casual Factors

The factors in the combinational causes of dust storms now may be listed and numbered for reference as follows:

1. Drouth
2. Exposed soils
3. Winds
4. Initial Electrostatic Forces
5. Unstable atmospheric conditions (of two kinds)

(Note: The probable involvement of another un-identified causal factor seems to be indicated by dust storms of Class III as listed below.)

It will be convenient to regroup the above factors into those which have their origin in terrestrial or atmospheric phenomena. Such classification will give:

1. Terrestrial
   - Drouth
   - Exposed soils
   - Initial electrostatic forces
2. Atmospheric
   - Winds
   - Atmospheric instability—due either to (a) adiabatic conditions or (b) to an intruding (usually colder) air-mass, often "polar continental."

Kinds of Dust Storms

Classes

On the basis of (a) causal factors[5]; (b) nature of the transported materials; (c) their mode of transport, three general classes of dust storms have been recognized:

I. Rectilinear Storms
II. Rotational Storms
III. Ebullitional Storms

Species

Because of minor but quite obvious other differences, these

[5]Keith, B. Ashton. "Dust Storm Problems." *The Minerologist,* Portland, Oregon, Aug. 1943, p. 229-31.

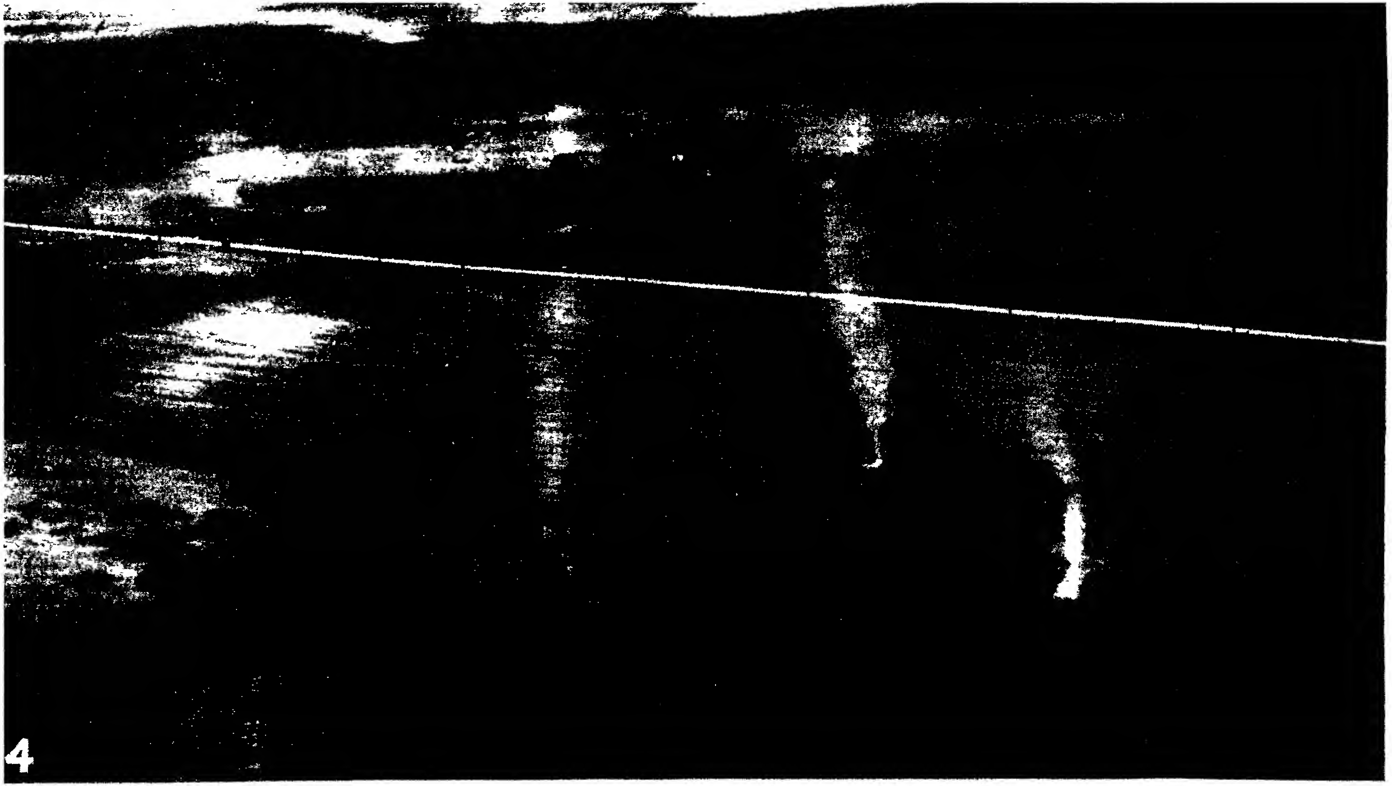

FIGURE 4.—Class II, Species 4, "Dust Whirl." Nine in sight. (Rotation is around a vertical axis.)

fundamental groups may be separated into seven species. Logically and naturally these species arrange themselves as follows:

Class I—Rectilinear Dust Storms

First Species—"Sand-blows" (Causal factors—1, 2, and 3)

Second Species—"Straight-blow dusters" or simply "Dusters" (the commonest form. Causal factors—1, 2 and 3, but intensified)

Class II—Rotational Dust Storms.

Third Species—"Rolling dusters." Rotation on a horizontal axis. (Approaching the observer this form appears as a long, rising, black wall which, on near approach seems to be rolling forward in a manner that is startling or even terrifying to the uninitiated. Most commonly these occur with the arrival of a polar continental[6] air mass. Causal factors—1, 2, 3, 4, and 5b. Often accompanied by lightning and thunder.)

Fourth Species—"Dust-whirls." Rotation on a vertical axis. (Causal factors same as for Species 3, except that the unstable conditions of the air seem to be due to high lapse rate, with possible involvement of only slight amounts of atmospheric electricity. Its presence was suspected by Gautier[7] and Blactin[8], Free[9], et al.)

Fifth Species—Shartans "Dust Spouts" or "Dust Devils"[10]. Rotation on a vertical axis. (Rare in America. Several "spouts" each resembling a water-spout in form, usually are reported together. Only six occurrences recorded in the United States so far as is known. Causal factors probably same as Species 4, but with the electrical forces tremendously intensified. No photograph is shown.)

Class III—Ebullitional Dust Storms.

Sixth Species—"Boiling Dusters" (Ebullitional movements of vast amounts of fine-grained dust to great heights, a characteristic in areas of origin. Causal factors—1, 2, 3, 4 and 5a).

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[6]Petterssen, Sverre. "Atmospheric Instability." *Introd. to Meteorology,* 1941, p. 61.
[7]Gautier, Emile. *Sahara, the Great Desert* (1935) p. 15.
[8]Blactin, S. C., "Dust" London, 1938, p. 222-264.
[9]Free, E. E. and Stuntz, "Soil Movements in the Winds" U.S.D.A. Bull. 68, 1911.
[10]Keith, B. Ashton, "A Summation of the Available Data on Dust Spouts or Shartans, Bull. 214, Institute of Sciences, Washington, D. C., 1944.

FIGURE 6.—Class III, Ebullitional Dust Storm, Species 6, "Boiling Duster."

FIGURE 7.—Class III, Species 7, "Funnel Storm."

Seventh Species—"Funnel Storms". Spiral and ebullitional upward movements of dust in enormous quantities to heights of 3 to 4 mi. Transport of dust by these storms 2000 to 3000 miles has been many times reported. All the known causal factors are involved. Also these are indications of the possible involvement of an obscure factor in storms of Species 7 as noted below.

The only forms of dust storms listed here are those that often have been seen; that many times have been photographed; and that also have been reproduced at will in miniature by various laboratory procedures, using forces of proportionally equal intensity.

Attention is called to the use of simple descriptive terms in the above classification, terms such as are in wide use among the inhabitants of the Great Plains country. Some of these terms have already appeared in the literature.

More extensive descriptions of each class and species must await future publication because of the present limitations of space. Tabulations of data on additional experiments also are omitted for the same reason.

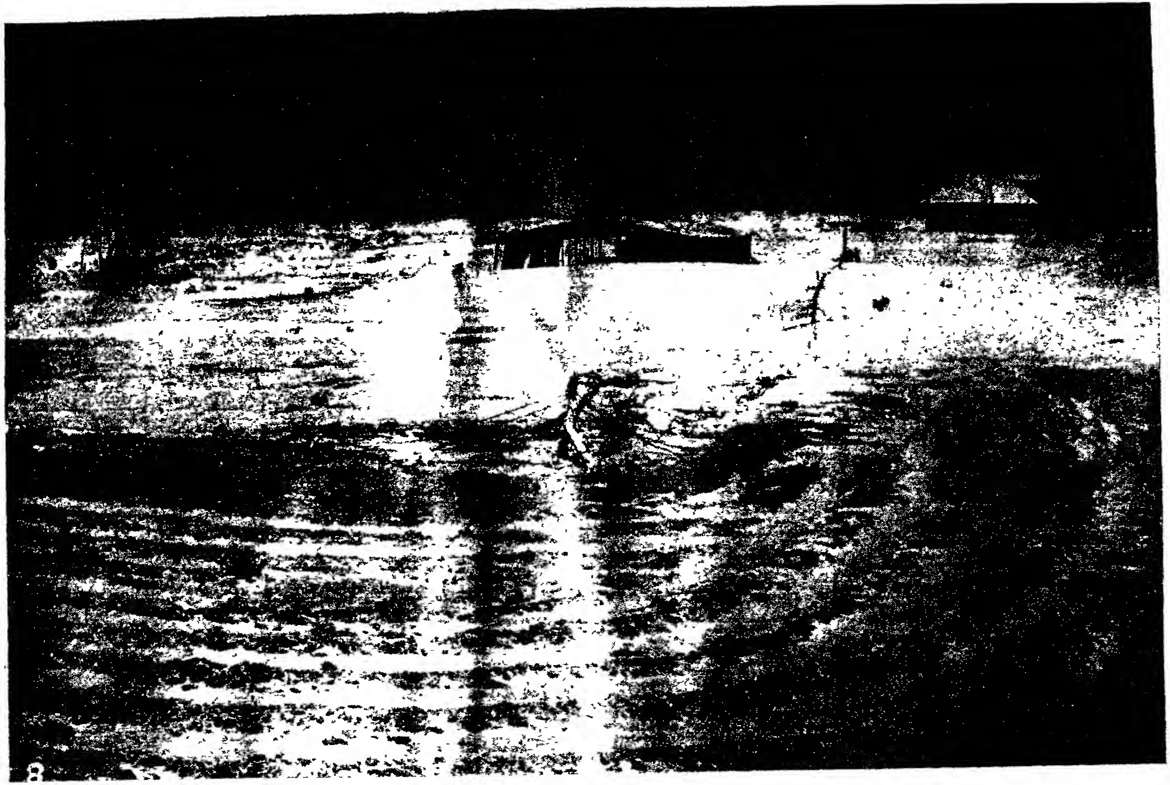

FIGURE 8.—Abandoned farm in Morton County, Kansas, 1939. Again producing wheat in 1943.

Why Do Some Colleges Reach a Higher Level of Achievement Than Others?

HOMER B. REED
Fort Hays Kansas State College, Hays.

INTRODUCTION

It is the problem of this paper to find some of the factors that cause differences in achievement between colleges. As a measure of achievement in college, two tests were used, the Michigan Vocabulary Profile Test and the Graduate Record Examination. Three possible causes of differences were investigated: the intelligence of students, the cultural background of students, and the amount of scholarly production by faculty members. As a measure of intelligence the Henmon-Nelson Test of Mental Ability for College Students was used. As a measure of cultural background, a questionnaire prepared for the purpose by the writer was used. As a measure of scholarly production, the number of titles of papers or exhibits published by faculty members between July 1, 1939, and June 30, 1941 was used. Because of the difficulties of making a comparative study, the investigation was limited to two state liberal arts colleges, called K and M.

College K, founded as a teachers college in 1902 but converted into a state liberal arts college in 1931, is located in an agricultural area in Kansas. College M, a liberal arts college organized as a part of a long-established university, is located in Michigan, and draws most of its students from industrial and urban centers.

The Michigan Vocabulary Profile Test, prepared by Dr. Edward B. Greene of the University of Michigan, is a multiple-choice vocabulary test consisting of thirty important words selected from each of eight fields: human relations, commerce, government, physical sciences, biological sciences, mathematics, fine arts, and sports. Since this test was standardized with a large sample of students from College M the test medians were assumed to represent the average achievement of that institution. At College K, one-half day was set aside for the administration of the tests. The students were not required to take the tests but were urged to do so as a matter

of interest. The date set for the test was April 24, 1941. The turnout for the students was very satisfactory—a total of 670 students, or 67.4 per cent of the total enrollment.

Results

The general character of the results may be most easily seen by comparing the average scores and corresponding test percentiles of students at College K on the Michigan Vocabulary Profile Test with test medians for each class. The scores for these points are given in Table 1 and Figure 1.

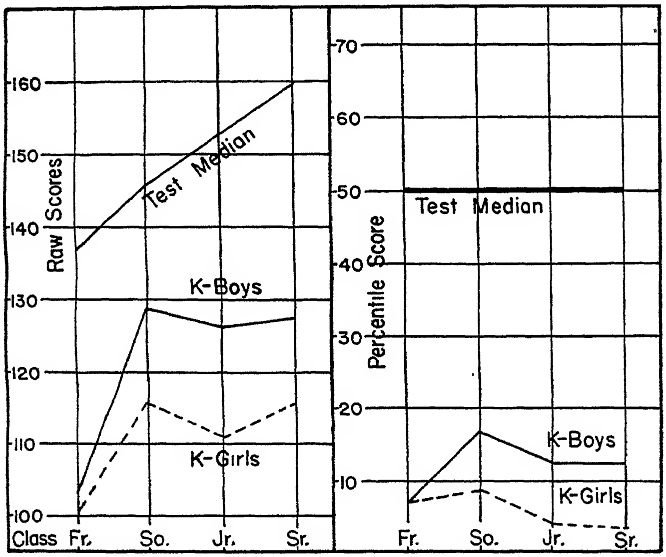

Figure 1.—Median achievement in Michigan Vocabulary Profile Test of college K boys and girls by classes. The curves on the left are based on raw scores and those on the right on percentiles.

The first striking result is that the K students, on the average, rank far below the test medians. How much below they rank relatively may be seen from the percentile scores. The median achievement of the K students ranges from the third percentile for the senior girls to the seventeenth percentile for the sophomore boys. On the whole, only 8 per cent of the K students equal or exceed the test medians. The second striking result is that the K students reach their maximum score in the sophomore class and then decline, while the test medians show a consistently increasing score from freshman year to senior year. These results raise the question of the

adequacy of the norms. The manual accompanying the test states that the published norms are based on 4677 cases. A letter from the author of the test to the writer states that the populations tested were samples from the University of Michigan, Oberlin College, New York University, Ohio State University, and several smaller colleges. It would appear that the sampling is adequate from the institutions represented, but it is possible that the institutions in which the test was standardized are very superior in the entire group of American colleges and universities. If this is true the comparison between the average achievement of K students and test norms established in other colleges should be much more favorable.

TABLE 1.—Average Scores, Michigan Vocabulary Test, College K, April 24, 1941.

	No. taking test	% taking test	Human Relations	Commerce	Government	Physical Sciences	Biological Sciences	Mathematics	Fine Arts	Sports	Total	Per cent of K students reaching or exceeding median
Freshman												
Boys	125	58.2	14.6	10.6	14.2	11.3	14.0	13.6	10.5	15.8	103	7
Girls	210	76.6	15.6	11.4	14.8	8.0	13 9	13.6	10.9	12.5	100.5	7
Test Median	......	......	17	18	19	12	15	19	15	20	137	....
Sophomores												
Boys	78	55	16 1	15.6	18 0	14.2	16 1	17 4	11.5	18 9	129	17
Girls	102	93 6	16 2	14.4	16 7	10.1	15 6	14 9	12.6	13.4	115.3	9
Test Median	......	......	19	19	20	13	18	20	15	20	146	....
Juniors												
Boys	35	39.5	16.1	16.0	16.9	14.6	15.8	16 9	11.5	18.1	125.8	12
Girls	49	79	16.1	14.7	16.2	9.6	14.7	14.9	11.6	12.6	110.3	4
Test Median	......	......	20	20	20	14	19	20	17	21	152.5	....
Seniors												
Boys	41	62	17.3	14 2	17 8	13 4	15 9	16 7	12.1	18.5	127	7
Girls	30	81	18	13 2	16 0	9 8	16 7	15 9	14.4	11 7	115.8	3
Test Median	......	......	21	21	21	15	21	21	18	21	160	....

An opportunity to make such comparison was provided by the results of the Graduate Record Examination, which was administered to the K seniors in May, 1942. This examination, sponsored by the Carnegie Foundation for the Advancement of Teaching, consists of nine comprehensive tests, one in vocabulary called Verbal Factor and one in each of the following subjects: mathematics, physics, chemistry, biology, social studies, literature, and fine arts. Among others the following sets of norms are supplied with this examination:

1. Norms for seniors based on the scores of 3990 senior men at the following colleges and universities: Allegheny, Am-

herst, Bowdoin, Dartmouth, Hamilton, Lehigh, Middlebury, Union, and Wesleyan.

2. Norms for first-year graduate students, one set based on scores of 830 students from Brown, Columbia, Harvard, Princeton, Rochester and Yale, and another set based on the scores of 685 first-year graduate students in the state universities of Iowa, Michigan, Minnesota, and Wisconsin.
3. Norms for seven midwestern colleges, based on the scores of 641 senior men from Antioch, Cornell, Hiram, Knox, Macalester, Michigan State, and University of Michigan.

The comparison between the scores of K seniors and these norms is shown graphically in Figure 2, in terms of standard scores for the various subjects. These standard scores were obtained by

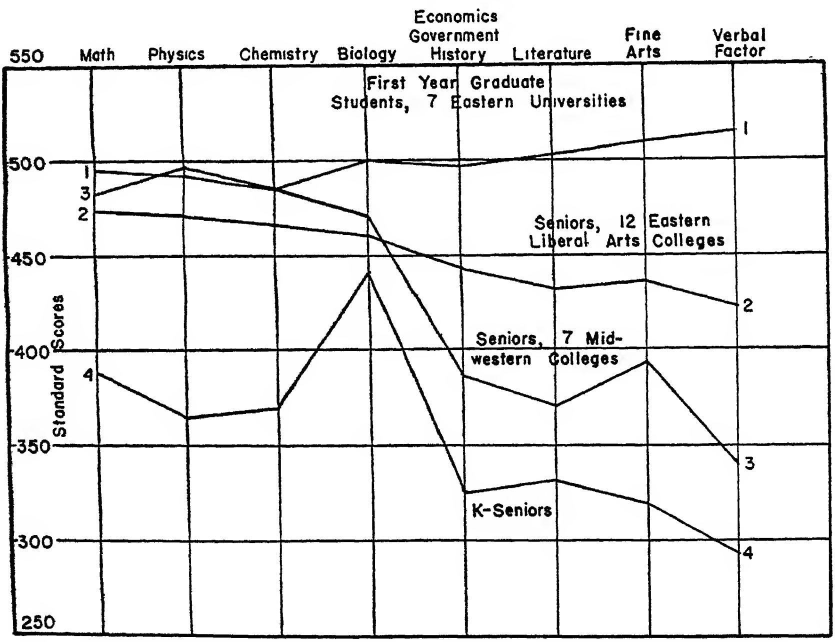

FIGURE 2.—Average achievement by subjects in Graduate Record Examination.

converting the raw scores from the various tests into general scores based on normalized distributions of first-year graduate students from eastern universities. The general mean is 500 and the standard deviation is 100. The seniors from 12 eastern liberal arts colleges rank on the whole one-seventh of a standard deviation below this

mean, the seniors from seven midwestern colleges are seven-tenths of a standard deviation below it, and the K seniors are one and six-tenths standard deviations below it. In terms of percentiles, this signifies that the mean of the seniors in the eastern liberal arts colleges lies at the forty-first percentile of first-year graduate students in eastern universities, the mean of the seven midwestern colleges lies at their twenty-sixth percentile, and the mean of the K seniors lies just below their fifth percentile. From the foregoing results it appears that the K seniors have about the same relative position in the Michigan Vocabulary Profile Test and in the Graduate Record Examination, and this result in spite of the fact that the examinations are very different in character and have been standardized in different institutions. There is, therefore, no reason for questioning the adequacy of the norms except that they were obtained from rather restricted regions.

Having stated the differences in achievement, the next step is to describe the tests by which the causes of these differences were investigated.

The Cultural Background Questionnaire was administered to the K students at the same time as the Michigan Vocabulary Profile Test. The Henmon-Nelson Test of Mental Ability for College Students, was administered to the K students when they entered the college as freshmen. In order to make comparisons with the students of College M, the Cultural Background and Henmon-Nelson tests were given to a sample population of 163 students in College M by one of the members of the sociology department in that college.

The Cultural Background Questionnaire referred to above asked for the student's name, date of birth, high school from which he graduated, classification in college, sex, degree or certificate sought, vocation preparing for, last year of school completed by father, last year of school completed by mother, father's occupation, whether or not a daily paper came to parent's home, magazines coming to parent's home, semester hours completed in different fields of knowledge, number of books read voluntarily between September 1 and May 1 in fiction and in non-fiction, hours each week spent in work, whether or not a regular study program was followed, and the number of hours per week spent in study.

The amount of scholarly production was measured, as stated before, by the number of contributions to educational or scientific journals or to public exhibits during a two-year period. For written

products each book or article in a man's field that was printed in a verifiable and purchasable educational or scientific publication counted as one. For artistic products (paintings, drawings, or works of sculpture) each piece having a name and given a public exhibit or published in an art magazine counted as one. For College M this information was obtained from the regularly published *Bibliography of Publications* for the period July 1, 1939 to June 30, 1941. For College K it was obtained from a bibliography furnished by the president's office. The titles published during 1940 and 1941 were counted but unpublished papers and theses were not counted. The total number of products for each institution for the period was divided by the number of faculty members having the grade of instructor or better to provide comparable measures for the two institutions.

The comparisons of the two schools on the intelligence and cultural background measures and on the scholarly products of the faculty are given in Table 2.

TABLE 2.—Comparison of Results on Intelligence, Cultural Background, and Faculty Production.

	College K	College M
1. *Average intelligence score* (Henmon-Nelson Test)	40.7	51.9
2. *Educational goal*		
Per cent seeking A.B. degree	23	73
Per cent seeking B.S. degree	51	17
Per cent seeking other degree	26	10
3. *Vocational goal*		
Per cent professional	73	82
Per cent farming	7	0
Per cent housekeeping	7	3
Per cent commerce	13	15
4. *Parent's education*		
Median grade completed, father	8	13.6
Median grade completed, mother	11	12.75
5. *Average magazine score*	20.6	27 6
6. *Average number of books read voluntarily between Sept. 1 and May 1*		
Fiction	3.3	7.0
Non-fiction	1.9	4.1
7. *Average number of hours work per week*	10.4	9.45
8. *Per cent following study program*	49.0	48.0
9. *Per cent parents taking daily paper*	86.0	100.0
10. *Average hours study per week*	22.0	22.1
11. *Scholarly production by faculty*		
Average number products per faculty member for two years	0.6	2.85
Per cent of faculty members contributing	34.0	62.0

From this table we see that the M students excell the K students in intelligence score by an average of 30 per cent; that although both groups of students are in the liberal arts colleges most of the M students seek the A.B. degree while most of the K students seek a B.S. degree which carries a teaching certificate; that a large majority of both groups is preparing for a profession; that the fathers of the M students on the average have 70 per cent more years of

formal schooling; that 100 per cent of the parents of M students take a daily paper as against 86 per cent of the parents of the K students; that the parents of M students take 35 per cent more magazines; that during the school year the M students read on the average 142 per cent more fiction books and 368 per cent more nonfiction books than the K students; that the M students work on the average of 10 per cent fewer hours per week; that about half of each group follows a study program; that both groups study approximately the same number of hours per week; that the average scholarly production per faculty member is 400 per cent greater at College M than at College K, and the proportion of faculty members participating in the production is nearly 200 per cent greater.

The student comparisons in Table 2 may be subject to sampling errors. This is very small for the K students because, with the exception of the intelligence scores, results are based on two-thirds of the student body. The sampling error in the case of the M students was reduced somewhat by the fact that the students were not volunteers but were given the tests as a part of courses in sociology. The students used were 42 sophomores, 50 juniors and 71 seniors. In the opinion of their instructors these students were representative of the student body in general.

Although there are large differences in cultural background between the M and K students, the existence of a difference is no proof that it is significant for achievement in college subjects unless we can show a significant correlation between the amount of the difference in question and the size of the score in scholarship. In the case of K students a study was made of the significance of each of the principal factors in the Cultural Background Questionnaire. The influence of the occupations of parents was investigated by classifying the vocabulary scores of pupils according to the occupations of their parents and then calculating and comparing the average scores. Each of the other factors named was investigated by correlating a numerical measure of it against the total vocabulary score.

The relation of the vocabulary score to the father's occupation may be seen from the results in Table 3. It shows that the average score is practically the same for each of the occupations given. The absence of relationship is undoubtedly due to the fact that college work selects students of a certain mental level regardless of the parental occupation.

TABLE 3.—Average Scores in Michigan Vocabulary Profile Test Distributed by Occupations.

COLLEGE K		
Occupation	Average	Number
Professional	112	84
Farming	110	100
Commercial	112	87
Skilled Labor	114	50
Unskilled Labor	109	6

As a preliminary to studying the relationship between school grades and vocabulary test scores, average grade points at the end of the spring semester in 1941 were computed for K students. In the grading system used, grade A equals five, B equals four, C equals three, D equals two, and F equals one. The number of credit hours in the subject was multiplied by the proper factor and then the total of points was divided by the total number of credit hours accumulated.

It was thought that the magazines taken in the home might give a measure of the culture of the home. To get a rating on the quality of the magazines, a questionnaire was sent to a number of the faculty members at K college asking them to rank a check list of magazines in the order of merit for cultural value. From these ratings the average rank of each magazine was calculated and a scale value computed for each. If a student reported a magazine which was not rated in the scale it was given the rating of a magazine judged to be equally good. For example, *Fortune* was given the same rating as *Atlantic* and *National Geographic* the same rating as *Life*. The scale values for the magazines named in the check list were as follows:

TABLE 4.—Magazine Rating Scale.

Harper's Monthly	8.0	Life	4.8
Atlantic Monthly	7.6	Popular Mechanics	4.7
Time	6.7	Woman's Home Companion	4.7
Readers Digest	6.5	Ladies Home Journal	4.7
Newsweek	6.1	Any religious magazine	4.3
Saturday Evening Post	5.1	Any farm or trade magazine	4.0
Colliers	4.9	Look	3.0
Popular Science	4.9	Wild West	2.3
Good Housekeeping	4.8	True Story	2.0

The magazine index for each student was derived by adding the scale values of the magazines taken in the home. Such a sum takes account not only of the quality but also the number of the magazines taken.

In Table 5 we find the correlations between total vocabulary score and each of seven other factors. The 200 cases used as a basis for the correlations were derived from an alphabetical list of

students as follows: first forty freshman boys, first forty freshman girls, and the first twenty boys and girls from each of the other classes.

TABLE 5.—Correlations Between Michigan Vocabulary Profile Test and Other Factors.

Intelligence	0.496	±0.036
Grade point average	0.525	±0.036
Hours work per week	0.036	±0.047
Hours study per week	0.066	±0.047
Magazine index	0.137	±0.046
Father's education	0.082	±0.047
Mother's education	0.004	±0.048

In this table we see that the total vocabulary score has a significant relationship with intelligence and grade point average but almost no relationship to each of the other factors, except possibly the magazine index, which shows a correlation of 0.137.

The correlation between intelligence and vocabulary score probably means that intelligence is an important, but by no means the only factor in college achievement. The correlation between grade points and vocabulary score can only mean that these two scores measure to some extent the same thing, namely, college achievement. The absence of significance in the relationship with factors other than intelligence and grade point is rather surprising. It is reasonable to suppose that hours of study would be a significant factor if other factors could be kept constant. Whatever influence hours of study has is probably counterbalanced by other factors such as intelligence and effectiveness of study methods. Similarly it would appear that amount of involuntary reading would be a factor in college achievement, but without an exact record of the amount and kind of reading and its relation to the criterion of college achievement, its influence is difficult to measure.

The amount of publication on scholarly production by the faculty would also seem to be a factor in the achievement of students. A teacher who keeps abreast of and participates in the solution of the new problems in his field ought to be a better teacher than one who treats his subject as a closed field. Against this we hear it said that the research worker is usually a poor teacher. But how shall we measure the influence of scholarly production upon the achievement of college students? This is still an open question.

After this study of the results of college achievement tests, the question arises as to what can be done to increase the achievement of the K students. Because of lack of space we shall here merely summarize the principal recommendations made to the president of

college K. It was recommended that the administration emphasize increase in quality of work rather than increase in enrollment; use more care in the selection of students; require a minimum level of achievement as a condition of staying in college; and urge faculty members to follow the normal distribution in grades. The faculty, upon which most of the responsibility for better scholarship falls, should make heavier assignments, devise more varied teaching methods, grade more strictly, put more emphasis on subjects showing excessively low achievement, devise means for publicizing and spreading culture among all the people, and give some comprehensive test of college achievement once a year.

Summary

This study was undertaken to explore some of the factors that cause one college to reach a much higher level of achievement than another. For practical reasons the study was limited to a comparison of sample populations of two colleges, K and M. It was found that in the Michigan Vocabulary Profile Test, which was standardized in part at M, the K students ranked on the average below the tenth percentile. An opportunity to check this ranking was provided from the results of the Graduate Record Examination, which was administered to all the K seniors in May, 1942. It was found that on this measure also the average position of the K seniors was below the tenth percentile of the scores made by students in twelve eastern liberal arts colleges.

Three factors—intelligence of students, cultural background of students and scholarly production of faculty members—were investigated as possible causes of the difference in achievement. It was found that on the average M students have a 30 per cent higher intelligence score, that their parents have spent a much longer period in formal education and take more and better magazines, that the M students read 142 per cent more fiction books and 368 per cent more non-fiction books, but they spend no more time in study than the K students.

By statistical techniques it was shown that father's occupation, hours work per week, hours study per week, and amount of parental education had no significant relationship with college achievement as measured by the tests used, but intelligence score and grade point average had significant correlations with it. The magazine index also appeared to be somewhat significant. The influence of voluntary

reading and of faculty production was not measured. Our statistical results reveal only one significant factor that accounts for the difference in average achievement between two colleges, namely, intelligence, but presumably there are many other factors which we have not measured and have not even named. It may be that the significant factors are differences in quality of teaching, college regulations, college traditions, zeal for scholarship, teaching load, salary level, and leadership.

To the writer the study of the causes of differences in achievement by different colleges appears to be a promising field of research. It is hoped that other studies will be able to avoid some of the limitations of this study; such as possible inadequate sampling of the population of the colleges studied; using one sample for the measure of achievement and a different sample for the measure of the factors that influence achievement; and using the norms made in one region and kind of institution as a standard for a different region and institution.

Some recommendations were made for the improvement of the achievement of K students.

The writer wishes to acknowledge his obligations to the staff members of college K and M who assisted him.

The Seventy-Sixth Annual Meeting

At Topeka on September 1, 1868, the Kansas Academy of Science was organized in Lincoln College. Lincoln College, later to become Washburn University, was then located at the corner of Tenth and Jackson streets. The exact attendance at this first meeting is not known but there probably were not more than a dozen present. The only contemporary account of the meeting the editor has found was that given in the *Topeka Weekly Leader* for September 17, 1868, and which reads:

> Pursuant to a published "Call," the friends of natural science, desirous of securing the benefits arising from association, and of giving a more systematic direction to scientific research in our state, met at Lincoln College, Topeka, Kansas, Sept. 1st, 1868, and organized a State Natural History Society. The various branches of natural science were assigned as follows:
>
> B. F. Mudge, A.M., Geology.
> F. H. Snow, A.M., Zoology.
> J. S. Whitman, A.M., M.D., Entomology.
> J. H. Carruth, A.M., Botany.
> Maj. F. Hawn, Meteorology.
> J. A. Banfield, Ornithology.
> Jefferson Robinson, M.D., Inorg. Chem.
> S. E. Sheldon, M.D., Comp. Anat.
> John D. Parker, Ph.D., Paloxontology.
>
> It was resolved that each active member should present a paper on some topic of Natural Science at each annual meeting, and that there should be two public lectures delivered annually before the society. The society is desirous of securing the publications of scientific bodies, and of obtaining specimens, by exchange or grant, of every description.

Most of those listed in the account given above were from Topeka. In addition, Manhattan, Lawrence and Wyandotte were represented. Two years later the name of the Natural History Society became the Kansas Academy of Science.

The change which the years have brought since 1868 was emphasized when the Academy began its second seventy-five years of existence at its birth-place, the seventy-sixth annual meeting being held at Washburn University, Topeka, on April 15, 1944. Well over two hundred persons were in attendance at the various sectional meetings. This attendance came from 23 cities of the state and represented over 26 institutions!

A report of the meeting made by Dr. John C. Frazier, the secretary of the Academy, was published in *Science* for June 23, 1944.

Dr. Frazier's account concisely summarizes the main events of the meeting and is herewith re-published almost in its entirety:

The seventy-sixth annual meeting of the Kansas Academy of Science was held at Topeka, Kansas, on April 15, with Dr. Harvey A. Zinszer, Fort Hays Kansas State College, Hays, Kansas, presiding. The affiliated society, the Kansas Entomological Society, met with the Academy. Other state societies which met with the Academy were the Kansas Association of Teachers of Mathematics and the Kansas chapter of the Mathematical Association of America.

During the day section meetings were held for Botany (interpreted broadly to include Bacteriology and Agronomy), Chemistry, Geology, Physics, Psychology and Zoology. No attempt was made to hold a section of the Junior Academy because of the transportational difficulties, but local chapters had been encouraged to hold meetings at which the outstanding demonstrations, papers and exhibits were selected. In certain instances local civic clubs provided prize money for the winners. The Academy council voted that high-school science clubs which are members of Science Clubs of America may become members of our Junior Academy of Science without payment of our membership fees.

The annual banquet was held in the evening with the newly installed president, Dr. Leland D. Bushnell, presiding as toastmaster. I. D. Graham, of Topeka, who became a member of the Academy in 1869, was present. Dr. Harvey A. Zinszer as retiring president gave the address, entitled "Famous Early American Observatories." The banquet was followed by the annual public meeting. The program for this meeting consisted of an invitational address by Dr. Joel Stebbins, director of the observatory, University of Wisconsin, and research associate, Mount Wilson Observatory. His subject was "The Heavenly Spaces." This technical subject was presented in an interesting manner.

The total attendance was 210. The reports of the section chairman are presented herewith in Table 1. The next annual meeting of the Academy will be held at Kansas State College, Manhattan, Kansas.

TABLE 1

Name of Section	Chairman for 1944	Number of papers on program	Number attending	Chairman for 1945
Botany	Stuart M. Pady	12	40	Elva L. Norris
Chemistry	Worth A. Fletcher	9	30	Harry H. Sisler
Geology	W. H. Schoewe	8	10	J. R. Chelikowsky
Kansas Entomological Society	Elmer T. Jones	10	20	W. T. Emery
Kansas Chapter of Mathematical Societies of America	Paul G Eberhart	7	60	Edison Greer
Kansas Association of Teachers of Mathematics	Herbert H. Bishop	7	60	Sara Belle Wasser
Physics	Ernest K. Chapin	7	18	P. S. Albright
Psychology	Maurice C. Moggie	11	21	Homer B. Reed

The following officers were elected for the next year and meeting: President, Dr. Leland D. Bushnell, Kansas State College; President-elect, Dr. John W. Breukelman, Kansas State Teachers College, Emporia; Vice-president, Dr. Claude W. Hibbard, University of Kansas; Secretary, Dr. Donald J. Ameel, Kansas State College; Treasurer, Dr. F. W. Albertson, Fort Hays Kansas State College; additional executive council members, Dr. Harvey A. Zinszer, Fort Hays Kansas State College; Miss Edith B. Beach, Lawrence High School; Dr. Paul G. Murphy, Kansas State Teachers College, Pittsburg; and Dr. Philip S. Riggs, Washburn Municipal University. Dr. Robert Taft, of the University of Kansas was reelected editor of the *Transactions* for a period of three years. Dr. Stuart M. Pady, of Ottawa University, was elected associate editor for a term of three years. Dr. John C. Frazier, of Kansas

State College, was elected for a three-year term as representative to the American Association for the Advancement of Science. Dr. M. J. Harbaugh, Kansas State College, was elected Academy librarian.

The official program as revised is given below:

GENERAL PROGRAM

Seventy-sixth Annual Meeting, Washburn University
April 15, 1944

8:45 to 9:25 Council Meeting, Mulvane Museum, Basement, Room 3.

9:30 to 10:20 General Meeting, Mulvane Museum.

a. Call to Order, Academy President Harvey A. Zinszer.
b. Welcome, President Byron S. Stoffer, Washburn.
c. A Brief History of the Kansas Academy of Science. (Prepared by the Secretary for A.A.A.S.)
d. The Crop Industries of Kansas. Dean L. E. Call, K. S. C.
e. Business session.
f. Announcements.

10:30 to 12:20 Sectional Meetings.

Botany, Rice Hall, third floor, Room 30-A.
Chemistry, Rice Hall, first floor, Room 10.
Geology, Mulvane Museum, basement, Room 3.
Physics, Crane Observatory, first floor, Room 10.
Psychology, Mulvane Museum, first floor, Room 15.
Zoology, Rice Hall, basement, Room 5.
Entomological Society, Crane Observatory, second floor, Room 23.
Mathematical Societies, Crane Observatory, second floor, Room 21.

12:30 to 1:30 Luncheon, Westminster Presbyterian Church.

1:30 to 4:00 Entomological Society, Crane Observatory, second floor, Room 23.

2:00 to 4:00 Mathematical Societies, Crane Observatory, second floor, Room 21.

3:00 A.A.U.P. Discussion led by Mr. F. H. Guild, Director of Research for Kansas Legislative Council, on "A Retirement Plan for Faculties of Kansas Colleges." Rice Hall, third floor, Room 30-A.

4:00 Final Business Meeting, Mulvane Museum, Basement. Room 3.

4:30 Meeting of the New Council. Same room.

6:00 Banquet, Main Dining Room, Topeka Woman's Club, 9th and Topeka. Address of Retiring President Zinszer entitled "Famous Early American Observatories."

8:00 Public Lecture. An illustrated lecture entitled "The Heavenly Spaces" by Dr. Joel Stebbins, Director of the Observatory, University of Wisconsin, and Research Associate, Mount Wilson Observatory, Small Assembly Hall, Topeka Municipal Building.

SECTIONAL PROGRAMS

BOTANY

Chairman, Dr. Stuart M. Pady

10:30 a. m. to 12:20 p. m., Rice Hall, third floor, Room 30-A

1. Kansas botanical notes, 1943. Frank C. Gates, K.S.C.
2. Possibilities of soybean research in Kansas. E. L. Blackman, K.S.T.C., Emporia.
3. Prairie studies in west central Kansas, 1943. F. W. Albertson, F. H. K. S. C.
4. Penicillin. Clinton C. McDonald, U. of Wichita.

5. Characteristics and the origin of the Blackhull wheats, E. G. Heyne and L. P. Reitz, U. S. D. A. and K. S. C.
6. The root system of dogbane, *Apocynum cannabinum*. John C. Frazier, K. S. C.
7. An ecological study of four species of sumac in relation to development and growth on eroded soil. Ivan L. Boyd, Baker Univ.
8. Further studies on the occurrence and distribution of physiologic races of *Tilletia laevis* in Kansas. E. D. Hansing and L. E. Melchers, K. S. C.
9. A comparative study of natural and artificial revegetation. Andrew Riegel and F. W. Albertson, F. H. K. S. C.
10. Inflorescence of *Gonolobus leavis*. L. J. Gier, William Jewell College.
11. Elasticity of plant tissues. Otto Treitel, Fisk Univ., Nashville, Tennessee (By title).
12. Seed viability in flax. L. P. Reitz and F. E. Davidson, K. S. C. and Kans. Agr. Exp. Sta.

CHEMISTRY

Chairman, Dr. Worth A. Fletcher

10:30 a. m. to 12:20 p. m., Rice Hall, first floor, Room 10.

1. Research in waxes. Roy A. Bowers, U. of K.
2. Reduction of diazonium salts with alkaline formaldehyde. R. Q. Brewster and Carl Johnson, U. of K.
3. The prediction of scholastic success in general chemistry at the University of Wichita. Worth A. Fletcher, U. of Wichita.
4. Reactions in liquid ammonia. II—Reduction of hexavalent chromium compounds. Harry H. Sisler and Frank E. Jirik, U. of K.
5. The electrodeposition of lead in the presence of wetting agents. Robert Taft and Paul W. Renich, U. of K.
6. The allylation of cyclohexanone William E. Brownlee and C. A. Vander Werf, U. of K.
7. A correlation of some terms employed in theoretical inorganic and organic chemistry. Calvin Vander Werf and Harry H. Sisler, U. of K.
8. Possibilities for sunflower research in Kansas Lloyd McKinley, U. of Wichita.
9. The stability of vitamin A in an experimental poultry feed. D. B. Parrish, A E. Schumacher, and M. J. Caldwell, K. S. C.

GEOLOGY

Chairman, Dr. Walter H. Schoewe

10:30 a. m. to 12:20 p. m., Mulvane Museum, Basement, Room 3.

1. Modern fossils in ancient rocks: an hypothesis. Arthur Bridwell, Baker Univ. Museum, Baldwin.
2. A new idea on continental drift. J. R. Chelikowsky, K. S. C.
3. Early Pleistocene drainage problems in central Kansas. John C. Frye and Norman Plummer, State Geological Survey, U. of K.
4. Cheyenne and Kiowa sands: a comparison. Ada Swineford and Harold L. Williams, State Geological Survey, U. of K.
5. A lower Pliocene *Mylagaulid* from Trego county, Kansas. Claude W. Hibbard, U. of K.
6. Investigations on oil and gas in eastern Kansas. John M. Jewett, State Geological Survey, U. of K.
7. Note on a giant Kansas calamite. W. H. Schoewe, State Geological Survey, U. of K.
8. Glacial striae in Kansas: locality 14. W. H. Schoewe, State Geological Survey, U. of K. (By title.)
9. Notes on Artifacts found in Pleistocene gravels in Kansas. A. Allen Graffham, State Division of Water Resources and U. S. G. S.

KANSAS ENTOMOLOGICAL SOCIETY

Twentieth Annual Meeting

R. E. Bugbee, President; E. T. Jones, Vice President;
D. A. Wilbur, Secretary-Treasurer

Business meeting 10:30 a. m. to 11:30 p. m., Crane Observatory, second floor, Room 23

Presentation of Papers 11:30 a. m. to 12:20 p. m.

Presentation of Papers 1:30 p. m. to 4:00 p. m.

1. Insects and other arthropods collected in pasture grasses, waste lands, and forage crops. H. H. Walkden, U. S. D. A. B. E. & P. Q., Hutchinson; D. A. Wilbur, K. S. C., Manhattan.
2 The thirteenth annual insect population summary of Kansas—1943. R. C. Smith and E. G. Kelly, K. S. C., Manhattan.
3. Temporary immunity in alfalfa which is susceptible to attack by the pea aphid. Walter T. Emery, U. S. D. A. B. E. & P. Q., Manhattan.
4. Studies on the life history of *Melanotus fissilis* (Say). (Coleoptera, Elateridae). H. R. Byrson, K. S. C., Manhattan.
6. Insect photography with limited equipment. E. T. Jones and Perry A. Piper, U. S. D. A. B. E. & P. Q., Manhattan.
7. The role of sorption in the fumigation of stored grain and milled cereal products. R. T. Cotton, U. S. D. A. B. E. & P. Q., Manhattan, and H. H. Walkden and R. B. Schwitzgebel, U. S. D. A. B. E. & P. Q., Hutchinson.
8. Army camp mess hall and barracks fumigation. C .A. Bernard, Amer. Cynamid & Chemical Corp., Insecticide Dept., Kansas City, Missouri.
9. Importance of honey production during war times. R. L. Parker, K. S. C., Manhattan.
10. Corn earworm control. D. A. Wilbur, K. S. C., Manhattan.

JOINT SESSION

MATHEMATICAL ASSOCIATION OF AMERICA
KANSAS SECTION
and
KANSAS ASSOCIATION OF TEACHERS OF MATHEMATICS

Morning Session

10.00 a. m. to 12:00 noon, Crane Observatory, second floor, Room 21
Paul Eberhart, Washburn, Presiding

1. Algebraic functions. D. H. Richert, Bethel College.
2. Mathematics in the navy training programs. G. W. Smith, U. of K.
3. Mathematics in pre-radar training. A. E. White, K. S. C.
4. Mathematics in manufacture of aircraft. Edison Greer, Beech Aircraft Corporation.
6. Mathematics in the army air force program. O. J. Peterson, K. S. T. C., Emporia.
7. Placement tests fór air corps students. C. B. Reed, Univ. of Wichita.
8. The armed forces institute tests. Laura Greene, Washburn U.
9. Correlation of entrance test scores and term grades. W. T. Stratton in cooperation with J. C. Peterson, K. S. C.

11:45 a. m. Business session of Kansas Association of Teachers of Mathematics. Crane Observator. Room 21. Herbert Bishop, presiding.

Afternoon Session

2:00 p. m. Business session of the Kansas Section of the Mathematical Association of America. Crane Observatory, Room 21. Paul Eberhart, presiding.

2:30 p. m., Crane Observatory, Room 21

Herbert Bishop, Manhattan High School, Presiding

1. Random jottings from an instructor's notebook. C. B. Reed, Univ. of Wichita.
2. Pre-induction courses in mathematics. Edna Austin, Topeka High School.
3. The mathematics program in high school at present and in the post-war period. T. J. LaRue, Junction City High School.
4. Report of the committee on the improvement of instruction. Gilbert Ulmer, U. of K.

PHYSICS

Chairman, Prof. Ernest K. Chapin

10:30 a. m. to 12:20 p. m., Crane Observatory, first floor, Room 10

1. Low cost spark timer. H. L. Jackson and S W. Cram, K. S. T. C., Emporia.
2. Electronic voltage stabilizer. Daryl D. Errett and John Zimmerman, K. S. T. C., Emporia.
3. A summary of the interrupted arc investigation. J. H. McMillen, J. F. McKown, R. F. Calfee and J. R. Sites, K. S. C.
4. Airplane model to show forces. B. E. Sites, K. S. C.
5. A scientific classification of dust storms. B. Ashton Keith, Institute of Sciences, K. C.
6. Photoelectric and thermionic properties of nickel. A. B. Cardwell, K. S. C.
7. Some problems in photographic stellar photometry. Philip S. Riggs, Washburn Municipal Univ.

PSYCHOLOGY

Chairman, Dr. Maurice C. Moggie

10:30 a. m. to 12:20 p. m., Mulvane Museum, first floor, Room 15.

The annual business meeting of the Kansas Psychological Association was held at the beginning of the program.

1. The effect of shock treatment on autokinetic reactions of psychotic patients. Albert C. Voth, Topeka State Hospital.
2. Experiments on level aspiration and their implications for clinical psychology. Sibyl Korsch Escalona, The Menninger Clinic.
3. A report on accelerated students approved by the Board of Examiners. A. H. Turney, Chairman of the Board.
4. College success in relation to age of entrants. H. E. Schrammel, K. S. T. C., Emporia
5. Post-war educational plans of A. A. F. and A. S. T. trainees at Kansas State College. J. C. Peterson, K. S. C.
6. Learning and retention of concepts. Homer B. Reed, F. H. K. S. C.
7. The guidance program at St. John's Military School. Wilbert J. Mueller, St. John's Military School.
8. The theoretical and diagnostic significance of scatter. Roy Schafer. The Menninger Clinic.
9. Correlations between scores on modified Alpha Examination Form 9 and grades in various high school subjects. John DeMand, Concordia High School.
10. Computing stated percentile scores from grouped data by use of the calculating machine. H. E. Schrammel, K. S. T. C. Emporia.
11. Correlations of first semester college grades in mathematics with scores on the Kansas Mathematics Test and on the Iowa Physical Science Aptitude Examination. W. T Stratton and J. C. Peterson. K. S. C.

ZOOLOGY

Chairman, Miss Dorothea S. Franzen

10:30 a.m. to 12:20 p.m.; 1:30 p.m. to 2:55 p.m.
Rice Hall, Basement, Room 5

1. Some experiments on vitamin C deficiency and its effect on the blood of guinea pigs. Mary T. Hartman and Mary T. Schroller, K. S. C.
2. Some observations and experiments on social behavior in the domestic fowl. A. M. Guhl, K. S. C.
3. A checklist of Kansas mammals, 1943. Claude W. Hibbard, K. U.
4. Protozoan encystment. George M. Robertson, Ft. Hays K. S. C.
5. X-Ray induced chromosomal aberrations in *Apotetix eurycephalus*. Robert K. Nabours and Florence M. Stebbins, K. S. C.
6. The growth of the skeleton and the musculature of the cat. Homer B. Latimer, K. U.
7. A case of complete absence of the inferior vena cava in man. Homer B. Latimer and Herbert H. Virden, K. U.
8. Effect of an all plant ration on the resistance of an omnivorous animal to parasitism. J. E. Ackert, Dorothy S. Branson, and D. J. Ameel, K. S. C.
9. Some Mollusca from Greenwood County, Kansas. Alice E. Leonard and A. Byron Leonard, K. U.
10. New state records of Mollusca from Kansas. Dorothea S. Franzen, K. U. Lantern.
11. Anatomy of the alimentary canal of a fresh-water Pelecypod, *Amblema costata* (Rafinesque). Arthur E. Pullam, Lincoln University, Jefferson City, Missouri, and A. Byron Leonard, K. U.
12. The cactus moth, *Melitara dentata* Grote and its effect on *Opuntia macrorrhiza* in western Kansas. Robert E. Bugbee and Andrew Riegel. Ft. Hays K. S. C.
13. Mortality of snakes on the highways of western Kansas. R. E. Bugbee, Indiana University, Bloomington, Indiana. (By title).
14. A malformed skull of *Aplodinotus grunniens* Raf. Morton Green, U. S. Army. (Study made at K. U.) (By title).
15. Reduced pituitary activity from the influence of sex hormones. E. H. Herrick and Irene Wassmer Hartman, K. S. C. (By title).
16. A case of extreme scaphocephaly from a mound burial at Troy, Kansas. Loren C. Eiseley and C. Willet Asling. K. U. (By title).
17. Spermatogenesis in *Pseudacris triseriata*. L. J. Gier, William Jewell College, Liberty, Mo.
18. Symposium on Mayr's "Systematics and the Origin of Species".
    - Book Review .... A. Byron Leonard
    - Ecology .... M. J. Harbaugh
    - Icthyology .... John Breukelman
    - Paleontology .... George M. Robertson
    - Botany .... F. C. Gates

KANSAS CHAPTER AMERICAN ASSOCIATION OF UNIVERSITY PROFESSORS

3:00 p.m., Rice Hall, third floor, Room 30-A
Prof. Edwin O. Stene, University of Kansas, Presiding

Discussion Leader: F. H. Guild, Director of Research for the Kansas Legislative Council.

Topic: A retirement plan for faculties of Kansas Colleges.

Transactions
Kansas Academy of Science

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A Survey of the Fossil Vertebrates of Kansas

H. H. LANE
Professor of Zoology and Vertebrate Paleontology,
University of Kansas, Lawrence.

From time immemorial, fossil remains have aroused attention, interest and speculation. What delight the small boy feels when, digging in a bank of soft rock, he finds there an imprisoned but rock-like sea shell or, if more fortunate, the remains of an insect of by-gone age. A stray huntsman, or a farmer plowing in a field, show scarcely less interest than the small boy when similar, or larger, finds come their way. The systematic study of these fossil remains has developed into a large and intricate field of science, the science of paleontology. From the findings of this science have come results of vast import to the biologist, the geologist and the philosopher and thus to the human race; in addition, these findings have had a great practical importance in the field of economic geology.

Kansas is particularly fortunate in possessing a rich store of these ancient animal remains and is equally fortunate in having a distinguished citizen who is able to describe them for us. The field of vertebrate animal fossils alone is so large that Dr. Lane has found it necessary to divide his review into several parts. Part I, published below, deals with ancient fishes; Part II will consider the fossil amphibia, reptiles and birds; and quite probably the description of ancient mammals, some huge, some small, will take two additional parts. All three remaining parts will appear in future issues of the TRANSACTIONS *but in order to add variety to our mental diet they probably will not appear in consecutive issues. At the conclusion of the series, however, we hope to collect all the articles into a single volume which will constitute a brief monograph in this field not previously reviewed*

Since these reviews are intended for the general scientific public, there has been included a geologic time table to aid the reader in recalling the geology of his college days. In addition, at the end of each review, there will be found a glossary of the more specialized words used by the zoologist and paleontologist.—The Editor.

PART I: THE FISHES

INTRODUCTION

There are few states in North America that have yielded a greater variety of fossil vertebrates than has Kansas. Primarily, perhaps, this is due to the fact that, geologically speaking, this state has lit-

erally undergone many "ups-and-downs", several times it has been buried under the sea, and several times, as a whole or in part, it has emerged to become dry land. Hence the proper conditions for the interment and preservation of animal remains have occurred frequently throughout longer intervals in the various periods and epochs represented here.

The oldest rocks cropping out in Kansas are those of Mississippian age in the extreme southeastern corner of the state in Cherokee County, mostly east and northeast of Baxter Springs. Elsewhere, from the Missouri state line westward in general almost to the Flint Hills the outcrops are of Pennsylvanian age. An area with a width varying from twenty-five to one hundred miles, or even more, reaches from Nebraska to Oklahoma in the form of a somewhat irregular, but *reversed* "L"; the base of the "L" extends from the eastern margin of the Flint Hills westward along the Oklahoma border to Meade County. These deposits are of Permian age and are predominantly of marine origin. After the deposition of these Permian strata, Kansas seemingly stood above the sea for a long time, so that throughout more than the first half of the Mesozoic Era no further deposition was made within its present limits. A very small outcrop of redbeds in southwestern Morton County, on the north bank of the Cimarron River, has been classified as Triassic. I know of no vertebrate fossils from this deposit. In the early part of the Cretaceous period (Comanchean), the Cheyenne sandstone and Kiowa shale were laid down. These rocks now crop out along the northern tributaries of the Medicine Lodge River some miles south and east of Greensburg and Coldwater, as well as north and west of Ashland. The Upper Cretaceous rocks (Gulfian), including the upper part of the Dakota, Graneros shale, the Greenhorn limestone, the Carlile shale, the Niobrara chalk and the Pierre shale, are extensively represented in the central and western parts of the state, and are prominently exposed in the Smoky Hills and Blue Hills areas in north and central Kansas, while finger-like extensions occur along the river bluffs to the westward, reaching the Colorado line along the Smoky Hill valley. In the western half of the state there are extensive formations of Tertiary age, (Miocene (?)* and Pliocene). Quaternary (Pleistocene) deposits are present most notably in the broad Arkansas River valley area, and in the eastern part of the state north of the Kaw. Other Quaternary deposits underlie the

*The question mark indicates that the age of the rocks has not been established definitely.

surface of the High Plains in the northwestern part of the state. In the northeastern corner of Kansas, as far south as Douglas County and as far west as Washington County, there are evidences of glaciation. The time relations of rocks exposed in Kansas is shown in Table I.

TABLE I.—A Time Chart of Rocks Exposed in Kansas.

Era	Period	Epoch	Age
Cenozoic	Quaternary	Recent	
		Pleistocene	
	Tertiary	Pliocene	Ogallala
		Miocene?	
Mesozoic	Cretaceous	Gulfian (Upper Cretaceous)	Pierre
			Niobrara
			Carlile
			Greenhorn
			Graneros
			Dakota
		Comanchean (Lower Cretaceous)	Kiowa
			Cheyenne
	Triassic?		
Paleozoic	Permian		
	Pennsylvanian		
	Mississippian		

TABLE I.—The oldest geological period shown here is the Mississippian; but by uplift, tilting and erosion, rocks in all the periods listed have been, in certain areas of Kansas, brought to the surface. These exposed areas are, therefore, sources of fossil remains. For a more extensive list of geologic periods, some of whose rocks are not exposed in Kansas, see Fig. B, page 172.

Thus there are exposed in Kansas (see Fig. A) deposits of Upper Paleozoic age (Mississippian, Pennsylvanian and Permian); of Mesozoic age (Triassic (?) and Cretaceous); and of Cenozoic age [Tertiary (Miocene? and Pliocene) and Quaternary (Pleistocene and Recent)]. Throughout the intervening periods not represented, Kansas was undoubtedly an elevated region of dry land. The strata named, together with certain (i.e., older) ones that do not crop out in this state but which have been penetrated in boring for oil and gas, dip to the northwest and extend to the Colorado line and beyond. Without considering the various sub-divisions of these deposits, this account of the geology of Kansas will suffice for the purpose of this paper.

FOSSILS AND THEIR COLLECTION

A fossil may be defined as any indication of an animal or plant preserved by natural means in the crust of the earth previous to historic time. The primary factor in the formation of fossils is

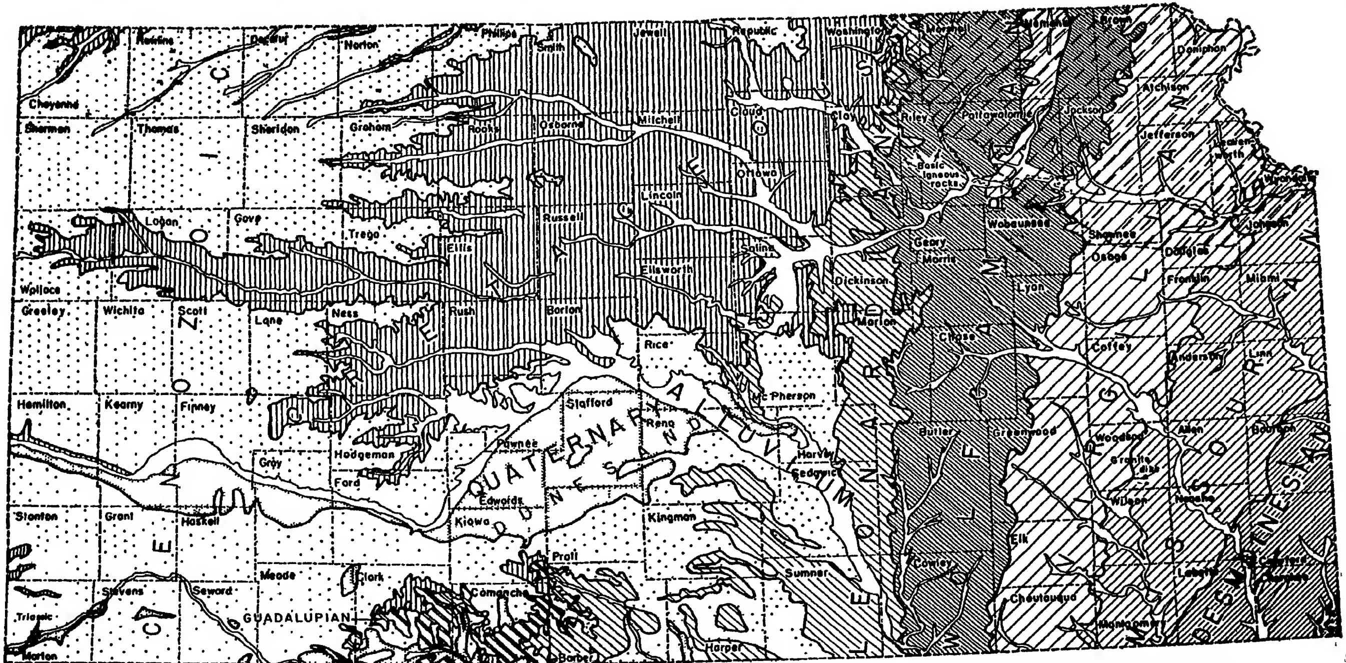

FIG. A.—Distribution in Kansas of Main Divisions of Outcropping Rocks. The Virgillian, Missourian, and Desmoinesian are subdivisions of the Pennsylvanian period mentioned in the text: the Wolfcampian, Leonardian and Guadalupian are subdivisions of the Permian; Alluvium (deposits from streams), and Dune Sand are of comparatively recent geologic origin. Note also the very small area of the Mississippian in the extreme southeastern corner of the state. This figure is reproduced through the courtesy of Dr. J. C. Frye, Acting Director of the State Geological Survey of Kansas and was taken from *Tabular Description of Outcropping Rocks in Kansas* by R. C. Moore, J. C. Frye, and J. M. Jewett, October, 1944.

quick burial and the retardation of decay in a deposit of mud or sand (*e.g.*, quick-sand), which soon hardens and resists erosion or other destructive agencies. Generally the harder, more durable parts, such as bones and teeth of vertebrates, but very rarely also soft parts, are thus preserved. In the frozen gravels of northern Siberia some 137 carcasses of the hairy mammoth, a common elephant of the "Ice Age", have been recovered in whole or in part with the flesh so well preserved in Nature's cold storage plant that it is still edible. The dry atmosphere of desert caves has, in a few instances, kept the bones and some of the flesh from decaying for centuries if not for thousands of years. Asphalt pits are natural traps in which many animals have been entombed and in some instances more or less completely preserved. Many fossils are *molds,* that is, *cavities* left in hardened soil or sand after the dead bodies there buried have slowly decayed and been gradually removed by percolating water. Such cavities carry on their walls definite imprints of the superficial structures of the organism. When, as usually happens, such cavities later become filled with a deposit of lime salts, sand, or other mineral substances, a *cast* results. This is a very common type of fossil. Where the organic matter of a buried bone or tooth is replaced, molecule by molecule, by mineral matter, *petrifaction* results. Contrary to the popular idea, petrifaction of animal remains is of comparatively rare occurrence, though common among plant fossils.

When an animal's body is buried in a peat bog, its tissues may undergo the chemical process of *reduction* and the tissues are reduced to elemental carbon. This process of carbonization has produced the coal from plants that we use for fuel. Carbonized animal remains are not common, but do occur, particularly in the shales associated with beds of coal. The indurated feces of animals, called *coprolites,* are sometimes found in a fossil state and have then afforded direct testimony to the nature of the food eaten by the animal in question. In other instances *tracks* have been left on the shores of lakes or of the sea, or on the banks of streams, in mud or sand which, when hardened, has preserved these indications of the animals that made them. A naturalist can now identify a beast by a track left in such places; so the paleozoologist can, with equal assurance, record the type of creature that left its impress on prehistoric mud.

Of the millions of individual animals of all sorts living at one time in any given area, comparatively few have the luck to die and be buried intact and quickly enough to become fossils. But even

when such a fate has befallen them, their remains are subject to all the vicissitudes of nature, and may be destroyed by erosion, crushed by movements within the earth's crust, or remain undiscovered by man. The *value* of a fossil *in the field,* in terms of dollars and cents, is *nil.* It is only when a fossil has been found, properly collected and treated to prevent injury, brought to the laboratory where it may be processed by means necessary to preserve it from atmospheric disintegration, removed from the enclosing matrix, its parts reassembled, (if, as usually is the case, they have been disassociated and scattered) and then studied to determine its exact place in the realm of animal life—it is only then, after all this elaborate processing, that a fossil acquires monetary value. This value is just what it has cost in time and labor to collect, prepare and preserve it for study or exhibition. The common belief that a fossil is worth its weight in gold is absolutely false.

The collection of fossils in the field, if properly done, requires experience and a knowledge of the correct technique that no one but a trained worker in this line possesses. Fossils cannot be dug up like so many potatoes with any hope of their permanent preservation. When found by one not so trained, they should be left undisturbed and called to the attention of some paleozoologist who knows what to do with them. Many scientifically interesting and important specimens have been ruined or destroyed because the finder did not know how to take care of them. Mere exposure to the air for some weeks, or even less, is usually sufficient to cause disintegration of a fossil that has not been protected by some hardening preservative.

Fossil collectors, then, should generally be men trained for this work in some school or museum. The technique involves methods of excavation, of hardening, of packing for shipment, and so on. Large specimens are enclosed in plaster casts such as a physician uses in the case of a broken leg. A field party should be provided with a truck, tents, canned or otherwise preserved food, tanks or large cans for water and gasoline, besides picks, shovels, collecting bags, shellac, paper, notebooks and minor tools of several sorts. Often such a party will spend weeks or months many miles away from human settlements and must be self-sustaining at all times. Fossils are looked for in regions known to be fossiliferous, or where deposits of the proper age occur. Sometimes the formations may appear favorable in every respect, yet contain no fossils at all, or only in scattered "pockets" that must be hunted for. When an end of a bone, or a tooth, is found protruding from the debris at the foot of a hill, it

becomes a "lead" and the area above is looked over carefully to find other remains in place. When found the specimen is carefully excavated, shellacked, wrapped in paper, and enclosed in a plaster cast. Careful records must be kept of the exact locality, the formation in which the specimen was found, and a field number given to identify it when later in the laboratory it is unpacked and processed, finally identified and labelled. All this requires a knowledge of geology, anatomy and the classification of animals, as well as ability to handle various sorts of tools, strength of body to endure hard work and long hours in the field. A fossil collecting trip is no vacation nor a time for pleasurable loafing. It means work, day in and day out, often under trying desert conditions, for "bad lands" are usually famous fossil hunting grounds.

Classification of the Vertebrates

The Animal Kingdom comprises all living things that are not plants—if we class bacteria, *et al.*, with the latter. Several major subdivisions, or branches, of the Animal Kingdom are recognized by zoologists, but that universally accorded the highest place in the tree of life is the group termed the vertebrates. Vertebrates are all those animals possessed of a skull and a "backbone" (*vertebrae*) of cartilage or bone, enclosing the brain and spinal cord. The vertebrae make up a linear series of skeletal segments that extends from the back of the skull to the end of the tail. In addition, vertebrates also have pharyngeal pouches and furrows, which in the lower forms develop actual openings between the pharynx (throat) and the outside world. In the fishes and some amphibians, these openings, when present, are usually called "gill slits", because organs for aquatic respiration (gills) develop on their walls.

Considering fossil as well as living vertebrates, one may recognize at least six divisions (technically called "classes") as follows:

1. AGNATHA, jawless vertebrates, usually also without paired appendages.
2. GNATHOSTOMATA, fishes with movable jaws and usually two pairs of appendages.
3. AMPHIBIA, including frogs, toads, salamanders and a great variety of their extinct relatives, usually with naked skin.
4. REPTILIA, turtles, lizards, snakes and many other forms with the skin covered with epidermal scales or scutes.
5. AVES, the birds, all with a covering of feathers.
6. MAMMALIA, vertebrates more or less covered with hair, warm-blooded and suckling their young.

Since we are considering the first two classes only in Part I, we may, for our convenience, name the following major divisions which include fossil as well as living fishes:

PHYLUM CHORDATA
- SUBPHYLUM VERTEBRATA
  - Class I. AGNATHA
    - Subclass 1. OSTRACODERMI
    - Subclass 2. CYCLOSTOMI
  - Class II. GNATHOSTOMATA
    - Subclass 1. APHETOHYOIDEA
      - Order Acanthodei
    - Subclass 2. CHONDRICHTHYES (ELASMOBRANCHII)
      - Order 1. Selachii
        - Suborder a. *Squaliformes*
        - Suborder b. *Raiiformes*
      - Order 2. Bradyodonti
      - Order 3. Holocephali
    - Subclass 3. OSTEICHTHYES
      - Division A. *Choanichthyes*
        - Order 1. Dipnoi
        - Order 2. Crossopterygii
      - Division B. *Actinopterygii*
        - Tribe a. *Ganodei*
          - Order 1. Chondrostei
          - Order 2. Holostei
        - Tribe b. *Teleostei*
          - Superorder (1) Physostomi
          - Superorder (2) Physoclysti

CLASS AGNATHA

The Class AGNATHA (from the Greek *a,* meaning "without", and *gnatha,* "jaws"), as the name implies, is a group of mostly extinct forms which have no movable jaws to close their terminal mouths. Here belong the earliest known fish-like vertebrates belonging to the Subclass OSTRACODERMI, as well as the living Subclass CYCLOSTOMI. The majority of the Ostracoderms now known are more or less completely protected by an armor of dermal plates of bone. Some few, like *Lasanius,* are naked or at most carry but little armor, so that it is likely that there may have been many unossified forms that have not been preserved as fossils. Because of the gaps in available collections that may have been occupied by these unarmored species, the Ostracoderms we do know fall into rather

sharply defined and well separated orders, the relationships among which are in fact mostly obscure. The earliest known belong to the Order *Pteraspida,* represented in the Middle to Upper Ordovician of Colorado, and elsewhere, by fragments too incomplete to give a clear picture of the species to which they belong. More complete remains of the *Pteraspida* come from the Upper Silurian, by which time, however, two other orders, the *Cephalaspida* and *Anaspida,* had also made their appearance. No representative of any of these three groups is known from deposits later than the Upper Devonian. The Pteraspids and Cephalaspids have the head and thoracic region of the body covered by bony shields; in some Anaspids, on the other hand, the head is covered by small scales, nowhere fused into a plate, and surprisingly enough, these head scales have their free edges directed forward. No trace of pelvic fins has ever been found in an Ostracoderm, and only the Cephaspids and some Anaspids have problematical appendages which some students of the group identify as pectoral fins. The caudal fin is "hypocercal", *i.e.,* resembling a heterocercal fin minus its upper (epichordal) lobe, but the tail as a whole is turned downward, thus tending to keep the animal on the bottom of the stream in which it lived.

The small amount of armor present on the Anaspidans needed only to be a little further reduced to leave the animal as naked as a modern lamprey, and there would be little else to distinguish these particular Ostracoderms from the *Cyclostomi,* the second subclass of the Agnatha. The living representatives of the Agnatha—the lampreys and the hagfishes—are at once highly degenerate and highly specialized but because of their relations to the "first fishes" are nonetheless of great interest to students of the vertebrates.

The Subclass OSTRACODERMI, so-called because of their extensive exoskeleton of bone, were bottom-dwelling, groveling forms living in freshwater streams from the muddy bottoms of which they scooped up muck with its content of decaying organic matter that served them as food. Covered on the outside with an armor of bony plates and scales, they were well protected against the few enemies they encountered, principally, no doubt, the invertebrate eurypterids, or "sea-scorpions", relatives of the modern king-crab, which only later took to the sea. The Ostracoderms themselves have left no known fossil representatives in the rocks of Kansas, though their fragmentary remains have been found in Ordovician (lower Paleozoic) deposits of Colorado. However, since they became wide-spread, practically cosmopolitan in their dis-

tribution by the Upper Silurian, it is almost certain that they lived here during one or both of these periods. But no Ordovician nor Silurian deposits outcrop in Kansas, hence their record in this state has been destroyed and lost. Of the later Agnatha, however, particularly of the Subclass CYCLOSTOMI, eight species belonging to three genera have been described by Gunnell from the Wabaunsee group, Americus lime, of the Pennsylvanian period, from a locality three miles west of Belvue, Pottawatomie County, Kansas. Ninety-six other species of fossil cyclostomes are recorded by this author from Lexington and Kansas City, Missouri, in the various shales of the Kansas City group. It is quite likely, therefore, that a careful search of the same deposits on the Kansas side of the line would bring them to light in our state also.

Since the endoskeletal parts of the cyclostomes are entirely cartilaginous, it is not surprising to find that the only parts preserved as fossils are the isolated "teeth", the hard tooth-like structures known as "conodonts",* which occur on the tongue and inner surface of the oral hood in the living lampreys. By means of these "teeth", the lamprey rasps away the skin of his victim, usually a fish, in order to suck its blood after the manner of a leech.

Class Gnathostomata

The second class of vertebrates is termed the GNATHOSTOMATA, because they are provided with movable jaws around the mouth. They developed from the AGNATHA through the backward extension of the Ostracoderm mouth by the obliteration of the first pair of gill-slits, or rather by the absorption into the mouth of these slits and the utilization at the same time of the skeletal elements in the first visceral arch as jaws. Each visceral arch included two rods of cartilage articulating at one end to form a movable >. These two rods needed only to be slightly enlarged to serve very well as the upper and lower jaw cartilages such as still occur in a modern shark, and thus to enable the Gnathostome to feed on larger prey than the Ostracoderm could use. The earliest known representatives of this Class, the *Subclass Aphetohyoidea,* occur in the Upper Silurian; by the Lower Devonian they had multiplied and diversified to become the dominant forms of their day. Although most of them did not persist after the Devonian, the

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*There is, however, no absolute certainty that "conodonts" are really, in all cases, the teeth of lampreys; in fact, for more than seventy-five years this question has been debated, and even today there are those who maintain that the conodonts are really the "jaws" of worms. We follow Gunnell, who considers them without doubt to be Cyclostome remains.

earliest order, the *Acanthodei,* had at least one representative in the Permian. Despite an auspicious start and several unique anatomical experiments, the *Aphetohyoidea* did not continue to improve the jaw apparatus as did the later Gnathostomes, in which the mouth-opening was extended still more posteriorly until it partially obliterated or absorbed the second gill-slit, a remnant of which, however, is retained to function as the spiracle, while the second, or hyomandibular, visceral arch behind the spiracle has lent its dorsal skeletal bar to give support to the jaws.

The *Aphetohyoidea* ("free hyoid") receive their name from the fact that in them the hyoidean gill-slit is not remodeled into a spiracle and consequently the hyomandibular element is *free* and does not take part in the suspension of the jaws as in the sharks. Although remains of Gnathostomes have been found in rocks of Mississippian age in Missouri, none has thus far been reported from Kansas until the Pennsylvanian. The earliest species, belonging to the *Aphetohyoidea,* had well developed dermal armor of bony plates or scales; the internal skeletal seems to have been entirely cartilaginous. They belong to the *Order Acanthodei,* and in them each fin, except the caudal, was provided with a stout but sharp-pointed bony spine on its anterior border. At first these little fishes, only three to four inches long, (*e.g., Climatius*) were experimenting in the development of paired fins—structures not often found in the Agnatha. The now current fashion of *two pairs* of such fins was finally adopted as the result of "trial and error", for some of these early forerunners of the later fishes had seven or eight pairs of lateral fins, arranged in a row on each side of the body. As time went on, they finally settled upon two pairs of such fins as the most practical arrangement. Not only did these early forms develop movable jaws, but they soon thereafter equipped these jaws with teeth. As stated above, the jaws were produced by the enlargement of the first or most anterior pair of gill-bars, supports previously of the anterior part of the respiratory apparatus. The teeth were modified placoid scales such as occur all over the body-surface of sharks today. It was necessary only that a fold of skin on the lips be drawn into the mouth and over the margins of the jaws to put several rows of these spiny placoid scales into position to function in the holding or tearing of the struggling prey. Even in living sharks this relationship of the scales to the teeth is obvious upon mere cursory inspection.

Besides *Climatius,* several genera of Acanthodians—all of small size, three inches to a foot long—have been found in rocks of Mis-

sissippian age from New York on the east to Oklahoma, Texas and New Mexico in the southwest. So, while their remains have not as yet been found in the *Mississippian* of Kansas, there is no reason why they may not occur in deposits of that age in this state also, especially since a species of Acanthodian (*Holmesella crassa*) has been reported by Gunnell from a deposit of *Pennsylvanian* age at a locality about three miles west of Belvue, Kansas, and several others have been collected within the city limits of Kansas City, Missouri.

Subclass 2. Chondrichthyes

In the Upper Devonian, the Subclass CHONDRICHTHYES, or cartilaginous Elasmobranchs, appeared, unquestionably the offspring of the *Aphetohyoidea,* and from their earliest known occurrence were already divided into two very distinct orders, the *Selachii* and the *Bradyodonti.* The *Selachii* are typically voracious, predaceous fishes with small eyes and large olfactory organs, obviously relying less on sight than on other senses to secure their prey. Their jaws are never fused to the cranium, but instead are attached at two points by means of ligaments (*amphistylic*) or later through the borrowed hyomandibular (*hyostylic*). The gill-slits open separately and directly to the outside and there is never a gill-cover (*operculum*). The *Selachii* were common in the Carboniferous and have numerous representatives living today. From some type closely resembling the primitive Upper Devonian *Cladoselache,* in which the paired fins appear to be unmistakably little more than segments of lateral folds of the body-wall, the line of descent can be traced to the modern sharks in which the pectoral fins have contracted bases.

Generally a shark has a fusiform shape but is somewhat laterally compressed in the tail region. Anteriorly, the head may be depressed (flattened) and extends forward into a snout or rostrum. The skates and rays, unlike the sharks, exhibit extreme dorso-ventral flattening of the head and body, until the width may become several times as great as the dorso-ventral dimension. Although both the median and paired fins are well-developed in the sharks, the pectoral fins in the skates and rays are relatively enormous and extend back on each side for the greater part of the length of the flattened body. In both sharks and rays, the pelvic fins are smaller than the pectorals. The caudal fin is typically *heterocercal, i.e.,* with the axis of the vertebral column turned upward from the base of the tail and with the greater expansion of the fin area *below* it; however, the caudal fin is only feebly developed in the skates and rays, where its locomotor function is taken over by the huge pectorals. In the later

PLATE 1.—Teeth of various types of fossil sharks.
Figs. 1 through 1l, Corax
Figs. 2 through 2m, 6 and 7, Isurus
Figs. 3 through 3c, Lamna
Figs. 4 and 5, Scapanorhynchus
The largest teeth are approximately 1½ inches long; the smallest, ¼ inches in length. From the plate in the paper by S. W. Williston, Kansas University Quarterly, 1900.

sharks, the snout may be modified in several ways, forming large lateral extensions (with the eyes at their distal ends) in the hammer-headed shark, or becoming of extraordinary length in the saw-fishes where it is bordered on either side with sharp, elongated "teeth". The mouth, with few exceptions, is located on the ventral surface of the head, well back from the end of the rostrum in most recent species, though in most ancient and a few modern sharks, it is terminal.

In the voracious, predaceous sharks the teeth are usually large and may be long, narrow, and pointed, or triangular, with serrated edges, or provided with several sharp cusps (Plate 1). In the skates and rays, on the contrary, the teeth are more or less flattened, with rough or ridged surfaces like a mill-stone, sometimes forming a continuous pavement, well designed to crush shell-fish and the like, which constitute most of their food (Plate 2). Although the active sharks hunt their prey mostly at the surface of the water, out in the open sea, the skates and rays live habitually on the bottom, usually in shallow water, where crabs and clams are most abundant.

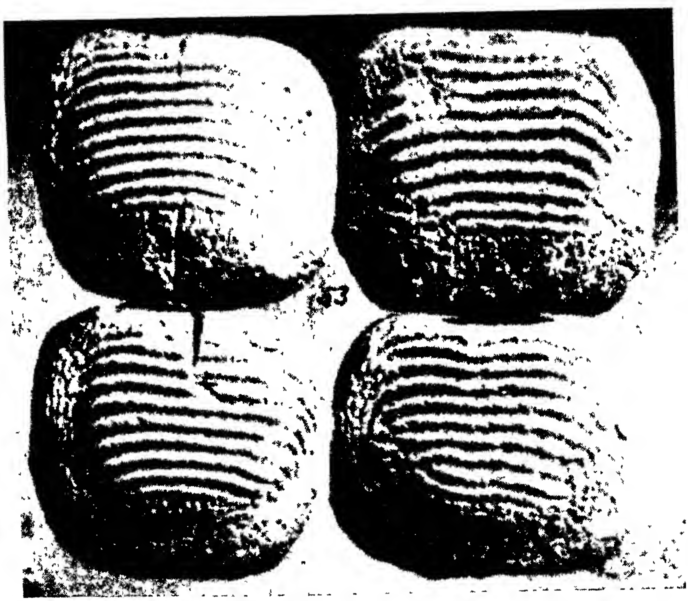

PLATE 2.—Fossil Teeth of Ptychodus. These grinding teeth as shown are about one-fourth greater than natural size. From Williston, Kansas University Quarterly, 1900.

The Selachians today are fishes with a cartilaginous *endoskeleton,* with no *bones* anywhere, but their earliest representatives did have a framework of bone, so that the modern condition is clearly the result of degeneration. The skull is now wholly a box of cartilage and is never overlain by dermal plates, such as are found in all higher groups. The skin is covered (in the earlier types) or has buried within it (in later types) plaque-like scales, usually rhomboidal in form. At first the outer surface of these plaques was smooth, but very early in the evolution of this group, each scale developed a sharp spine, which protrudes through the skin, while the plaque-like base is buried within the integument.

In Kansas, by far the greater number of fossil sharks occur in the Cretaceous. In the Lower Cretaceous (Comanchean), in the Kiowa shales of Clark County, have been found a number of the *Suborder Squaliformes.* Known only from scattered teeth, one of these genera is probably to be identified as *Odontaspis;* several other species, found in the same deposits, belong to the genus *Lamna* (Plate 1). Elsewhere over the northern hemisphere this genus is known from the Middle Jurassic to the present. Its family, the *Lamnidae,* all have two spineless dorsal fins, the anterior one of which arises in front of the pelvic fins. Their teeth, 300 or more in number, are large, pointed, with or without accessory cusps. The bodies (*centra*) of their vertebrae contain *four* radiating lines of calcifications.

However, this family is represented by a far greater number of species, belonging to several genera, in the Upper Cretaceous of Kansas. In fact, here these sharks may truly be said to be abundant. Some of them are of large size, rivaling in that respect, the larger species living today (30 to 40 feet). Yet not all the sharks from the Upper Cretaceous were so large, for, mingled with the *Lamnidae,* are at least three species of the little dogfish sharks, or *Scylliidae.* They too are characterized by the possession of two dorsal fins, as in the *Lamnidae,* but in this case the anterior dorsal lies over or even behind the pelvic fins. The bodies of their vertebrae have *eight* forked radial calcifications. Their teeth are small, numerous and pointed, generally with a larger central cusp and a pair of small accessory cusps. Although the dogfishes occur from the Jurassic to the present, as fossils they are not widely distributed. Members of this family are living today in the Atlantic Ocean along our coasts. The Kansas species (*Scylliorhinus rugosus, S. planidens,* and *S. gracilis*) are represented mostly by scattered teeth, which are

small. The accessory cusps vary much in relative size, but are always very much smaller than the central cusp. The smallest teeth of some of the *Lamnidae* are no larger than the largest teeth of the *Scylliidae,* but differ from them decidedly in shape. In them the enameled portion of the tooth is triangular in form, and accessory cusps are usually absent, except occasionally as mere vestiges. These teeth are found very commontly in Kansas in Upper Cretaceous deposits, usually disassociated and scattered about, though in rare instances several rows have been found more or less held in place by the calcified cartilage of the jaws.

Related to *Lamna* is the genus *Isurus.* A fine large specimen of *Isurus mantelli,* from the Niobrara chalk of Trego County, is in the Kansas University Museum of Vertebrate Paleontology, at Lawrence. It appears to have most of its numerous teeth in place. This species is not only one of the largest of Cretaceous sharks, but it is also one of the most common. Its disk-shaped vertebral centra, each with a central perforation for the accommodation of the persistent notochord, usually lie on one end in the chalk and suggest segments of a huge crinoid stem.

Seven species of *Lamna* itself (*L. appendiculata, L. sulcata, L. mudgei, L. macrorhiza, L. quinquelateralis,* and two unnamed) occur in the Niobrara and lower deposits of Kansas. Their teeth, except some of the most posterior ones, have a narrow, compressed, tapering central main cusp, with one or two pairs of very small pointed accessory cusps, or none at all. Other related genera recorded from the Kansas Niobrara include *Corax* with two species, *Scapanorhynchus* and *Leptostyrax* with one each.

But it must be acknowledged that, at best, the rather numerous recorded species of these sharks are known mostly from *disassociated* teeth, and positive identification to species, or even to genera, is hard, if not sometimes impossible to make. It is altogether likely that some species have been based on different teeth belonging to *one individual,* since there is a tremendous amount of variation in the size and shape of teeth in one and the same shark. This fact does not concern the identification of our Kansas sharks alone, for we find A. Smith-Woodward, the great English paleontologist, saying:—

"The specific determination of the detached teeth of sharks and skates is little more than guesswork, and to decide upon their generic relationships with any approach to certainty is also often very difficult."

Another family of selachians, found in the Upper Cretaceous of Kansas, differs so notably and distinctly from the true sharks in the form of the teeth (Plate 2), the shape of the body, and in the habits of life, that they can be distinguished at a mere glance. This is a family of the Suborder *Raiiformes,* called the *Myliobatidae—rays* rather than sharks. Nearly a dozen species recorded from Kansas belong to the genus *Ptychodus,* which has no less than 600 teeth in each jaw! These teeth are arranged in parallel rows and decrease in size from within outward, except that the median row in the upper jaws is made up of small, low-crowned, *smooth* teeth, which differ materially from the other teeth in the rows immediately adjacent to them. In *Ptychodus mortoni,* our commonest species, found only in the Niobrara, there are eight rows on each side of the median series, or seventeen rows in all. The lateral teeth are more transversely elongated, the surface ridges less well developed and the form more irregular.

The living Myliobatids are often known as "sea-devils", and are broad and flat with disk-like bodies. Many of them become very large, 15 to 20 feet long, and weigh a thousand pounds or more. A peculiarity not known to occur in our fossil species is found in the pectoral fins which in some living species take on almost the character of arms and are used in scooping up their food from the sea-bottom and transferring it to the mouth. The flat, pavement-like teeth are well fashioned for their task of crushing crabs and other shell-fish which constitute the bulk of their food. They are viviparous, *i.e.,* their young are born, not hatched, and for the most part they live in tropical or semitropical shallow seas. The presence of *Ptychodus* in the Upper Cretaceous of Kansas, therefore, suggests that the climate of this state at that time was probably similar to that of southern Florida today. More than a dozen species of this genus are known, all from the Upper Cretaceous in various parts of the world, and a few of them, including our most common one, *Ptychodus mortoni,* occur in Europe as well as here.

As noted earlier in this paper, the *Subclass Chondrichthyes* from its earliest known occurrence was already divided into two very distinct orders, the *Selachii* and the *Bradyodonti.* Numerous specimens of the *Bradyodonti* from deposits of Pennsylvanian age in Allen, Bourbon and Douglas Counties, Kansas, are in the collection of the Kansas University Museum of Vertebrate Paleontology. These are teeth of a very peculiar but most characteristic form and apparently belong to at least two species of the genus *Campodus,* or

to one very closely related to it. In these fishes the teeth in the anterior part of the jaws are sharply pointed and cutting in function, while those in the posterior part are flattened and ridged, adapted to crushing hard-shelled prey. Since the *Bradyodonti* evidently fed on shell-fish their upper jaw cartilages had to fuse with the cranium to give sufficient crushing power to cope with crabs and clams. They differ from the Selachians also in the absence of a spiracle and in the possession of an operculum. Arising in the Upper Devonian, they were common throughout the Mississippian and Pennsylvanian periods, but thereafter became rare, although a few survive to this day in the form of their modified descendents, the Order *Holocephali.* The idea was formerly widespread that *Campodus* and its related genera belong among the *Heterodontidae,* a family of sharks with one living genus (*Cestracion*) in the Pacific Ocean, popularly known as the Port Jackson shark. This is a very peculiar looking fish that reaches a length of only three or four feet. Its teeth are flat grinders for the easy crushing of shell-fish and it was their form, more than anything else that undoubtedly suggested the idea of a relationship to the Bradyodonts. In *Campodus* the broad, low-crowned posterior teeth lie in several rows in which *all* the teeth functioned simultaneously, whereas in sharks generally only the single marginal tooth in each row is in use at any one time.

Order Holocephali

A very distinct order of the Subclass Chondrichthyes is that called the *Holocephali,* known from the middle Triassic to the present. They have an elongated body, very large pectoral fins with simple cornified rays. The anterior dorsal fin has a stout spine resting upon a cartilaginous base to which it is attached by a simple articulation; the posterior dorsal fin is low but very long, merging behind with the long slender caudal. The teeth are few in number and peculiar in form. Above on each side there is a small anterior tooth and a larger posterior one; while below there is a very large mandibular tooth resting on the inner and upper margin of the jaw which meets its fellow of the other side at the symphysis. Generally there are several grinding cusps upon each of these teeth. Several genera of Holocephalans are found in deposits of Jurassic to Miocene age in Europe, where, however, they are rare; one genus, *Leptomylus,* occurs in the Upper Cretaceous of New Jersey, Mississippi and Wyoming; still others are known from New Zealand and Java. Until recently none was known from our state, but Moore in 1929 described *Physonemus striatus* from "the Pennsylvanian of Eastern

Kansas". Still more recently, in 1942, Hibbard described a new genus and species of a supposed holocephalan from the Niobrara Cretaceous of Logan County, Kansas. Moore's specimen consists merely of a fragmentary head-clasper, indicating a species about the size of those now living. Hibbard's specimen, likewise, comprises only a large head clasper, very much larger than the clasper of any living holocephalan. Hibbard calls his species *Ichthypriapus hubbsi.* Although some doubt is held as to its exact relationships, the probability is great that it is correctly ascribed to this order. Since holocephalans live today along our western coast in the Pacific, and since the Cretaceous sea that once covered a large part of Kansas was undoubtedly connected with the Pacific, it is altogether likely that representatives of this order were living here at that time. The specimen indicates the possibility that many other as yet unknown forms may be expected to come to light upon more intensive explorations than have been made heretofore in this state.

Class Gnathostomata: Subclass Osteichthyes

The groups of fishes hitherto considered were more numerous in the earlier periods of their existence than they are now, for they have undergone a slow but steady decline which began even before the end of the Paleozoic era. The next subclass, the OSTEICHTHYES, on the contrary, from its first appearance in the middle Devonian to the present, has steadily increased both in number of species and in relative importance as well. Even before the end of the Permian this group had not only attained the almost exclusive possession of the fresh-waters of the world, but it had also pushed out into the sea where its numerous species with their billions of individuals are now successfully contesting with the Chondrichthyes for supremacy.

Two Divisions of the OSTEICHTHYES are recognized, viz., Division A. CHOANICHTHYES and Division B. ACTINOPTERYGII. Under the first Division, CHOANICHTHYES, there may be found two orders, *Order Dipnoi* and *Order Crossopterygii.*

These groups were already distinct, though not so widely divergent as now, when the Osteichthyes are first encountered in the known fossil record. This fact means that they must have had a long antecedent history not yet recovered. As the name indicates, the endoskeleton of the Osteichthyes is predominantly osseous and exhibits numerous contrasts to that of the Chondrichthyes. Thus, as has already been pointed out, the jaws of a shark are merely car-

tilaginous bars or rods connected with the cranium only by ligaments, *i.e.*, they are never fused with it. In the Osteichthyes, on the contrary, the jaws are either entirely or partially encased with dermal bones which are fused with other dermal plates covering the outer surface of the brain-case (*chondrocranium*). The complex composite structure thus formed appeared here for the first time in the evolution of the vertebrates and emerges as a *true skull*.

Another highly important characteristic is found, early in the history of this subclass, in the development of an air-sac or lung. This lung is an organ of respiration and is not a specialization in late species of Osteichthyes, but was present in the very early primitive members of this group. *No known chondrichthyd ever had a lung or air-sac*. Numerous other structural developments could be cited in respect to various organs, notably the brain and the fins. Originally possessed of a *heterocercal* caudal fin, essentially like that in sharks, almost all the later members of the subclass have a symmetrical *homocercal* tail. However, in the Crossopterygii and Dipnoi, the usual type of caudal fin is the *diphycercal*. And, although in the earlier actinopterygians there was but *one dorsal* fin, there were typically *two* in the crossopterygians and dipnoans.

The exoskeletal scales and plates in the Osteichthyes are also osseous, in whole or in part, in contrast to the placoid scales of the Chondrichthyes described above. Yet these structures are characteristically different in the three groups, for the Crossopterygii and Dipnoi have scales of the so-called 'cosmoid' type in which the basal portion consists of bone tissue arranged in parallel layers, or *lamellae*, above which there is a layer of spongy bone enclosing a network of blood-vessels. The outer layer of the scale is made up of *dentine* (here called 'cosmine') containing numerous pulp cavities and overlain with a thin surface layer of *enamel*.

In many of the older, and in a few modern, Actinopterygii the scales are of a type called "ganoid", in which there is a laminated basal portion of *bone*, above which there is a central portion containing blood-vessels, then a thin layer of *dentine*, while the surface is made up of a series of lamellae of an enamel-like substance known as *"ganoine"*. However, in the more recent actinopterygians, the scales have become so modified that the cosmoid type no longer occurs, and the ganoid type is rare.

The paired fins of the bony fishes are now, in general, very different from those of the more recent sharks. In the early actinopterygians, however, these fins were essentially like those of such

primitive sharks as *Cladoselache,* for example, and comprised a broad basal plate embedded in the body-wall and supporting distally a number of parallel bars of bone or cartilage; hence the greater part of the fin is a web of skin supported by these parallel bars, while the basal part includes only a comparatively small fleshy lobe covered with scales. In the crossopterygians and lung-fishes, on the other hand, the basal lobe of the fin is generally comparatively large, while the web forms little more than a fringe about its margins. Moreover, the Crossopterygii developed a type of paired fin in which the bony axis clearly includes the same elements as are found in the limbs of the later tetrapods, though still retaining additional parts that are lost in the more recent or advanced forms.

The gills in the Osteichthyes are never more than five pairs in number, and lie in a common chamber on each side at the back of the head. This gill-chamber is covered by a large lid, called the *operculum,* and has but one opening to the outside. In addition to the gills for aquatic respiration, many of these bony fishes, as we have already noted, more especially the lung-fishes and the crossopterygians, developed a lung (or pair of lungs) from the ventral floor of the pharynx (throat), with which connection is maintained through an open tube, corresponding to our own "windpipe" (*trachea*). The causes behind this important achievement, without which no land-living animal could ever have appeared, have been suggested by Romer, who says:

"The explanation of this unexpected development of lungs in water-living forms is suggested by the habits of . . . [certain] . . . living types. . . . These live in regions (such as the upper reaches of the Nile) where there are alternate periods of rain and drought. During the wet season lungs are useless, but with the drying up of streams, with water present only in stagnant pools, ordinary fish die by the myriad, while those which have lungs may survive until the next rains. Devonian bony fish, as far as we can tell from the sediments, appear to have lived under quite similar conditions, in freshwater streams and lakes which were subject to periodical droughts. Lungs were a considerable asset to them under these circumstances" (Romer, *Vert. Paleo.,* p. 70).

In later actinopterygians, however, because of changed environmental conditions, these lungs have become the swim-bladder, an hydrostatic organ useful to its possessor in altering its specific gravity, when it wishes to float at a higher or lower level in the water.

DIVISION A. CHOANICHTHYES

The Choanichthyes are those more primitive Osteichthyes in which the selachian olfactory pit has been replaced by *external* and *internal* nares. This group early in its history underwent a divergence into two quite distinct orders, the Dipnoi and the Crossopterygii. This dichotomy has been manifest ever since the Middle Devonian. In dentition the Crossopterygians are the more generalized and primitive, the Dipnoans the more highly specialized. In skull structure the reverse is true, the Dipnoans are the more generalized and primitive, the Crossopterygians the more highly specialized in the development of the dermal bones that have been added to the cartilaginous chondrocranium to produce the skull.

The Dipnoi, or lung-fishes, constitute a very ancient order of fishes, once with numerous representatives throughout the freshwaters of most of the world, but today reduced to only three genera, one living in Australia, one in Africa and one in South America. They are moderately large fishes which, from their earliest known appearance in the Middle Devonian, have followed two rather distinct lines of evolutionary development, or, in other words, have become adaptively divergent in two directions. One line, represented by *Neoceratodus* of Australia, hard to distinguish from the fossil *Ceratodus* of the North American Permian to the Cretaceous has a single lung, *large* cycloid scales, and fins of the usual biserial type. The other line, represented by *Protopterus* of Africa and *Lepidosiren* of South America, has paired lungs, small scales, and appendages reduced to long slender tapering structures, like neither fins nor legs, though functioning, rather inefficiently to be sure, as legs, not fins. The earliest Dipnoans of the Middle Devonian were so similar to the contemporary rhipidistian Crossopterygians that they can be distinguished only by their more highly specialized teeth, but today *Lepidosiren* shows scarcely a single trait that resembles the early Crossopterygians.

From Kansas, Williston recorded *Sagenodus copeanus,* a dipnoan from the late Pennsylvanian (basal Wabaunsee) of Brown County. The specimen is merely a fragmentary cranial plate plus a number of dental plates and their supporting elements. However, the dental plates in particular are unmistakable and establish beyond question the existence of lung-fishes in Kansas in Upper Paleozoic times .

The second order of the Choanichthyes, the Crossopterygii, likewise has diverged into two very distinct suborders, the *Rhipidis-*

tia and the *Actinistia,* sometimes called the *Osteolepidoti* and the *Coelacanthini* respectively. It is from the *Rhipidistia* that the Amphibia and, through them, all the higher tetrapods are descended. In fact the relationship of the Crossopterygians to the primitive phyllospondylous amphibians is so close that it is not at all illogical to put the two groups together as some have done to emphasize this kinship. The primitive Crossopterygii had internal nares, well developed cerebral hemispheres, cosmoid scales, two dorsal fins and an anal, in which the supporting structures include usually a basal plate embedded in the muscles of the body-wall, and articulating with which are a variable number of segmented rays. But most significant of all is the structure of the *paired* fins, which consist of well-formed fleshy lobes surrounded by a membranous fringe (hence the name "fringe-finned" fishes, as the word "crossopterygium" signifies). The internal skeleton of these fins is so reduced from the primitive type of the selachians, for example, that only a single proximal element (*humerus* or *femur* as the case may be) articulates with the pectoral or pelvic girdle. Succeeding this single proximal element of the appendage there is next a pair of elements (*ulna* and *radius,* or *tibia* and *fibula*) clearly homologous to the bones so-named in the fore and hind limbs of tetrapods. The Rhipidistia are slender-bodied, early with a strongly heterocercal tail, but later developing a diphycercal caudal fin. No representative of this suborder is recorded from Kansas.

The suborder *Actinistia,* on the contrary, is a highly specialized division of the Crossopterygii, usually of small size but now represented by a living species of *Latimeria* over five feet long and weighing one hundred twenty-five pounds. Starting in the Upper Devonian and continuing to the present day they have persisted throughout a remarkably long period of time, but have apparently undergone very little change in structure. They are usually rather slender, fusiform fishes, in which the most obvious external characteristic feature is the tri-lobed diphycercal caudal fin. Two species have been described by Hibbard under the names *Coelacanthus neweli* (No. 786 F, K.U.M.V.P.) and *C. arcuatus* (No. 787 F, K.U.M.V.P.), both from the Rock Lake shale, Stanton formation, Missouri series, near the top of the Middle Pennsylvanian of the Mid-Continent, Anderson County, Kansas.

Other coelacanths have been recorded from only a few other North American localities, *i.e.,* from the Middle Pennsylvanian of Linton, Ohio; of Mazon Creek, Illinois; from the Mississippian

(Kinderhook) of Iowa; from the ?Triassic (Upper Banff) of Alberta, Canada; and from the coal measures of Nebraska.

The type of *Coelacanthus neweli* Hibbard is a nearly complete specimen with its skull crushed, 115 mm. long from snout to tip of caudal rays. It has two dorsal fins. The tri-lobed caudal and supplementary caudal are typical of this order. *C. arcuatus* Hibbard is represented by a less complete specimen. In both the scales are cycloid with a number of ganoid ridges on the surface of each. Moy-Thomas thinks that Hibbard's species are not distinguishable from Newberry's species from Linton, Ohio, now known as *Rhabdoderma elegans*. However that may be, the fact remains that Crossopterygian fishes did live in Kansas in the Upper Paleozoic.

Division B. Actinopterygii

Division B, the *Actinopterygii*, of the *Subclass Osteichthyes*, may be in turn divided into two "tribes", namely *Tribe a: Ganoidei* and *Tribe b: Teleostei*. The Ganoidei include two orders, *Order Chondrostei* and *Order Holostei*. The Chondrostei were numerous in the middle to upper Paleozoic, but have only a few rare or degenerate survivors today. The Holostei were mainly Mesozoic offspring of the Chondrostei, though with a very few surviving representatives today, and these wholly confined to the United States, such as the gars and the bowfin (*Amia*).

The Chondrostei include the oldest known actinopterygians, which were probably not far removed from the common ancestral stem of all the bony fishes. They have certain structural peculiarities, including a *heterocercal* caudal fin, which most of their descendants have exchanged for one of the *homocercal* type. Among the earliest Chondrostei, hence among the most generalized, were the *Palaeoniscidae*, represented among many other genera by *Cheirolepis* of the middle Devonian and *Palaeoniscus* in the Pennsylvanian and Permian. By the Jurassic, *Chondrosteus* itself had appeared and this genus persisted thence throughout the whole of the Mesozoic era, but gave way at the beginning of the Tertiary to its direct descendant, the genus *Acipenser*, the sturgeons, which comprise several species living today. Related to *Acipenser*, is the genus *Scaphirhynchus*, the little sterlet living in the Kaw River at the present time, and *Polyodon*, the paddle-fish, also a denizen of the Kaw and Missouri Rivers, as well as throughout the Mississippi basin generally. The polyodonts are known from the Upper Cretaceous, the sturgeons from the Eocene, to the present.

The Palaeoniscids had a slender body either naked or covered with angular or circular scales; the tail region was clothed with rhombic scales. The dermal bones of the skull were covered with enamel. Stout fulcra were present in the median line anterior to the dorsal, caudal and anal fins. The teeth were small, conical or styloid in form. Two unnamed species of *Palaeoniscus* are recorded by Gunnell from the Wabaunsee group, Americus limestone, Upper Pennsylvanian, at a locality three miles west of Belvue, Pottawatomie County, Kansas.

The second order of the Ganoidei, namely, the *Holostei,* is a large and somewhat heterogeneous group not easy to define. Its species are mostly extinct, only the bowfin (*Amia*) and the gars (*Lepisosteus*) living today and they are confined to the United States. The Holostei descended from the Chondrostei, whose place among fishes they usurped and held throughout the middle Mesozoic, only to give rise to the modern tribe of the Teleostei, in competition with which they were beaten and became reduced to the few (four) species now limited to American waters. Their unpaired dorsal lung functions in part in respiration but is mainly used as a hydrostatic organ.

The first known Holostean genus is *Acentrophorus* from the late Permian, but it was not until near the end of the Triassic that the order attained prominence; dominance was reached during the Jurassic when they were the most numerous and most important fishes of the period. By the Lower Cretaceous they had begun their decline and by the end of the Upper Cretaceous they were reduced to their present lowly position.

The most important fossil Holosteans hitherto found in Kansas belong to the family *Pycnodontidae,* a group characterized generally by the possession of a very high, oval, laterally compressed body, covered with ganoid scales rhomboidal in shape though higher than long, and in some cases restricted to the anterior part of the body. The caudal fin is deeply concave, externally homocercal, though inwardly weakly heterocercal. The pelvic fins are small and set *below* (not *behind*) the pectorals. The dorsal and anal fins are located behind the middle of the body-length; anteriorly high and pointed, they extend as a narrow hem all the way to the caudal fin. There are no fulcra, no suboperculum, no interoperculum and no gular plates. The upper jaw is toothless, but the roof of the mouth (*vomers*) carries five longitudinal rows of round or oval grinding teeth (Plate 3). The premaxillary is provided with chisel-shaped

cutting teeth. The lower jaw (*mandible*) is very stout with a high coronoid process and several rows of grinding teeth.

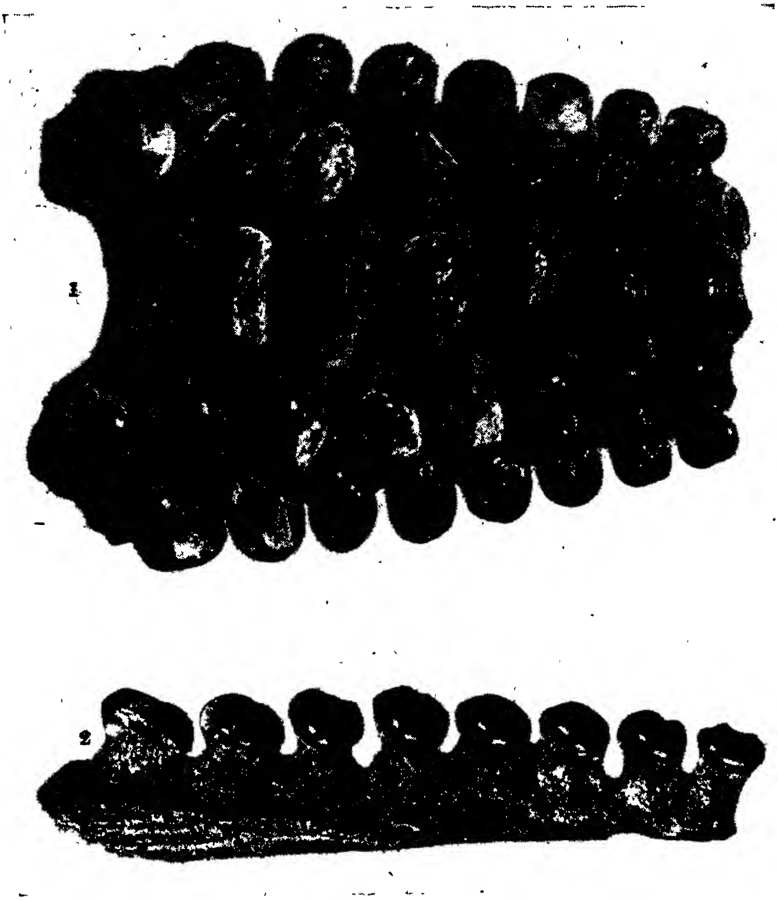

PLATE 3.—Fossil Pycnodont Teeth. These specimens, now in Dyche Museum, are shown at approximately 3/2 natural size. From Hibbard, *University of Kansas Science Bulletin,* 1940.

Of Holostean genera and species, *Coelodus stantoni* and *C. browni* were described many years ago by Williston from the Kiowa shales, Lower Cretaceous (Comanchean), near Belvidere, Kiowa County, Kansas, while *Pycnomicrodon kansasensis* is recorded by Hibbard and Graffham from the Upper Cretaceous of Rooks County. Hibbard has also described *Coelodus streckeri* from Russel County.

The Holostean family of the *Lepisosteidae* occupies a very isolated position in the order. The first known remains are from the Cretaceous of Egypt; from the Eocene to the lower Miocene they occur in the freshwater deposits of India and Europe; in North America they are known from the Eocene to the present. The living genus *Lepisosteus* has three species, popularly termed "gars," and itself is known in this country from the Eocene, being therefore one of our very oldest genera of living vertebrates. *Fossil* remains of Lepisosteus are known from the Pleistocene, Lincoln County, Kansas.

Another Holostean family is that of the *Amiidae,* possibly the most progressive of all its order, remains of which occur in the upper Jurassic to the Miocene of Europe; in the Cretaceous of South America; and from the Eocene to the present in North America. The *Amiidae* have thin *cycloid* scales and lack all traces of fin-fulcra. The vertebrae in the caudal region are notable for the presence of *intercentra, i.e.,* each vertebral body consists of two parts, about equal in size; the posterior part, or centrum proper, bears the neural arch above and the haemal arch below; the anterior part, or *intercentrum,* has no such processes. The dorsal fin is generally long, in *Amia* itself beginning anterior to the pelvic and extending thence backward to the caudal fin. This genus *(Amia)* first appeared in the Eocene of the United States and has persisted to the present time. Its occurrence now in Kansas waters, together with the gars, makes it also one of the very oldest of our living fishes—almost deserving the name a "living fossil." Popularly *Amia* is known as the bowfin, freshwater dogfish, and by nearly fifty other names in different parts of this country. Like the gars, it is a hardy, predaceous fish, little esteemed for food and disliked by fishermen because it is destructive to our food and game fishes. It is very tenacious of life and since it respires by means of its lung as well as by its gills, it withstands exposure to the air out of water for twenty-four hours or even longer. In damp or rainy weather it even travels overland from one water-course to another. *Fossil* remains of *Amia* are not yet known from Kansas, but since it has been recovered in nearby states, there is no reason to feel that it may not be reported from the Miocene, Pliocene or Pleistocene deposits in this state. It probably means that no especial effort has hitherto been made to find it.

Another family of the Holostei, called *Pachycormidae,* resembles the Amioids in so many respects that there can be little doubt

of their close relationship. Largely or wholly marine, they were as completely equipped for a predaceous mode of life in the open sea as the modern sword-fishes, both being provided with a rapier with which they could deal a mortal thrust to their prey or enemy. In the Pachycormids this rapier, in the form of a long conical, sharp-pointed rostrum on the snout, was composed of the fused ethmoid and vomerine elements of the skull. It extended forward far over and beyond the triangular, forwardly pointed intermaxillaries. Two long, fang-like teeth, rooted in alveoli, were borne on the vomer, while both the upper and lower jaws were slender and carried an inner series of large teeth and an outer series of numerous small teeth. The dentary bone of the mandible was provided anteriorly with two large fangs. The pectoral fins were extremely large. Our Kansas genus, *Protosphyraena,* is distinguished from the closely related genus, *Hypsocormus,* only by the lateral compression of its teeth, which have opposite sharp edges, and are set in complete sockets *(alveoli).*

Four species of *Protosphyraena* have been recorded from Kansas, three from the Niobrara Cretaceous and one, *P. bentoniana,* from a lower level "in the Lincoln marble, on Rock Creek, in southern Mitchell county" (Stewart). *P. recurvirostris* came from the Niobrara Cretaceous of Gove county; *P. penetrans,* from the "Niobrara Cretaceous, western Kansas"; and *P. gigas,* from the "Lisbon shales, Fort Pierre Cretaceous, one mile north of Lisbon, Logan county, Kansas." Otherwise, this genus is known from the English chalk, from the Cretaceous of France, Maastricht, Egypt and Patagonia. *Protosphyraena* is perhaps most notable for its enormous pectoral fins, which were first described by Louis Agassiz, over a century ago. They are very long and are composed of more than forty rays, generally divided distally, but flat and compressed proximally, and are all fused together. The anterior margin of this fin carries tooth-like projections from which there extend grooves transversely across the breadth of the fin. The pectoral fin articulates with the coracoid and the scapula by eight basal segments, of which the upper two overlap each other.

The genus *Martinichthys* was proposed by McClung to include Cope's *Erisichthe ziphioides* and six additional species (new) from the Niobrara Cretaceous of Trego County, Kansas. Specimens of the new genus had previously been confused with *Protosphyraena,* with which, however, it seems not to be even closely related. *Martinichthys* has a rostrum widely different from that of *Protosphy-*

raena; "the extreme length of the skull from tip of rostrum to occipital condyle is 200 mm., of which the complete rostrum occupies a little more than 50 mm., so that in the matter of size there is considerable difference. The entire structure of the skull so far revealed in the new genus is lighter and more delicate. . . . Most striking, however, is the entirely opposite types of dentition in the two genera. *Protosphyraena* presents a type of the highest development in the dental armature, with its strong, sharp, and firmly socketed teeth on the maxillaries, premaxillaries and vomers, while in the new genus there is an apparent absence of teeth except weak denticles disposed over the roof and floor of the mouth" (McClung).

Tribe B: Teleostei

The second Tribe of the *Actinopterygii* is termed the *Teleostei,* and it comprises a vast array of species, both living and fossil; it is impossible (if it were desirable) in a paper of this length to give all its families due consideration. It is necessary here, then, to name and describe very briefly and in order only those species most commonly found in Kansas.

The *Teleostei* are "bony" fishes of types most familiar today, in which the skin is either naked (*e.g.,* in the catfishes) or covered more or less completely with thin cycloid or ctenoid scales, more rarely by ossified plates. The vertebral column is completely ossified, and throughout the whole body "fish-bones" (ribs, etc.) are more or less plentiful. The caudal fin is homocercal. Fulcral scales are never found in connection with the fins. The opercular apparatus, covering the gill-chamber, is well developed. The optic nerves cross but do not form a chiasma. There is no spiral valve in the rectum, and spiracles are lacking on the head.

The distinction between the *Holostei* and the *Teleostei* rests partly upon the character of their respective scales and partly upon internal anatomical structure, *e.g.,* the latter have an ossified supraoccipital which the former lack. However, these two orders are very closely related and the line of demarcation between the *Amiidae* and the more primitive physostomous *Teleostei* is in some cases almost obliterated. This obliteration is especially true in the case of the scales, which in the *Amiidae* are already thin and elastic and are in no wise different from those of some physostomous teleosts, in which, below the external glossy layer, another fibrillar one is developed by osteoblasts (bone-cells). The caudal fin in the teleosts is always outwardly homocercal, while inwardly there is generally a strong upward bend of the posterior end of the vertebral column.

This condition is correlated with the notable development of the lower fin rays. In the vicinity of the last vertebra and the posterior haemal arches there develops a single *hypural plate.* The more primitive teleosts, on this account sometimes called the *Physostomi,* have the swim-bladder still connected with the throat by an open duct; in the more advanced the swim-bladder has lost all connection with the throat. In the former, this organ is a thin membranous sac, richly furnished with capillary blood-vessels, and functions in respiration especially for the elimination of carbon dioxide, though probably not to receive air from the atmosphere. In the more advanced teleosts, where the swim-bladder is no longer connected with the throat—hence the term *Physoclysti* applied to such fishes—this organ is filled by the diffusion of gases from the surrounding tissues and has no part in respiration; it has become wholly an hydrostatic organ.

The largest and by all odds the most striking fossil Teleost in Kansas is a primitive physostomous genus commonly known as *Portheus,* but more properly called *Xiphactinus.* It belongs to the suborder *Isospondyli,* which comprises many species, but is very hard to characterize or define since most of its characters are negative or primitive. Thus one notes that the fins are without spines, hence supported only by the relatively soft and flexible rays. The pelvic fins are abdominal in position—a primitive feature, since in the more advanced teleosts the pelvics have moved forward to stand close to, or even in advance of the pectorals. The air-bladder in the *Isospondyli* still has direct connection with the throat through an open tube. The upper jaw is also rudimentary and in many instances toothless. While the earliest isospondylids occur in the Jurassic, they did not become numerous until the Upper Cretaceous. However, from then to now they have been abundant, as witness the huge numbers of living herrings, salmon, trout and tarpon.

Xiphactinus (Plate 4) belongs to the family *Ichthyodectidae* which is characterized by the possession of a laterally compressed skull with powerful jaws carrying only a single row of cylindrical teeth, and with no foramina nor notches below the internal alveolar border. No predentary element is present; and the vertebrae are deeply grooved and have pits above and below for the insertion of the neural and haemal arches. The supraoccipital, which completely separates the paired parietals, has a large median longitudinal crest. The opercular mechanism is complete, and there are branchiostegal rays, but there appears to be no gular plate. The fin-rays are notably

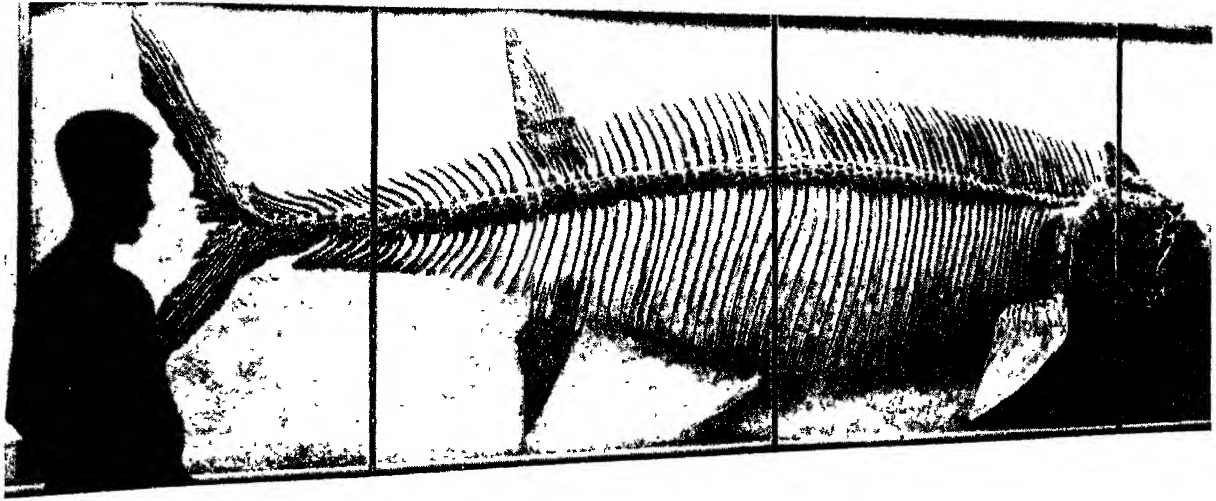

PLATE 4.—Xiphactinus. This huge fossil fish, some fourteen and a half feet in length, is one of the most perfect specimens in existence. It is on exhibit in Dyche Museum. The three vertical black lines shown in the photograph support the glass windows behind which the fossil is mounted. The illustration narrows because the photographer had to make his record on film at a considerable angle in order to include the full length of the specimen. The young man at the left observing the specimen also furnishes a scale to judge the size of the giant fish.

stout and segmented, if at all, only at their distal ends. The pelvic fins are abdominal in position, and the caudal is deeply forked. These were large, some very large, predaceous fishes with the teeth set in sockets on the margins of the premaxilla, maxilla and dentary, but with no teeth on the vomers, palatines nor pterygoids.

Xiphactinus is related to the tarpon, but lived in the seas of the Niobrara Cretaceous time. It reached a length of twenty feet or even more. It was a predaceous fish with its large conical, sharp-pointed teeth, irregular in size, and fixed in sockets on the margin of the premaxillaries, maxillaries and dentaries. On the skull there is a large median supraoccipital crest. The fin-rays are notably stout, and divided, if at all, only at their distal ends. The pelvic fins are abdominal in position, and the homocercal caudal fin is widely forked. Williston, commenting on this genus in Kansas, says: ". . . from the size of the jaws and the powerful dentition we may suppose that they rivaled the Mosasaurs, the smaller ones at least, in strength and ferocity."

Seven species of *Xiphactinus* have been recorded from the Upper Cretaceous of Kansas by Leidy, Cope and Stewart, though at least two of them are probably only synonymns. The five recognizable species are: *X. audax* Leidy, *X. lowii* Stewart, *X. brachygnathus* Stewart, *X. lestrio* Cope, and *X. mudgei* Cope. Cope's species *X. molossus* and *X. thaumas* seem to be indistinguishable from Leidy's *X. audax*.

Of smaller size, but closely related to *Xiphactinus,* are the genera *Gillicus* and *Ichthyodectes,* all, in fact, members of the same family, the *Ichthyodectidae.* These genera may be distinguished by the following key from Williston.

a. Teeth large, of unequal length.......................................*Xiphactinus*
b. Teeth medium, of equal length....................................*Ichthyodectes*
c. Teeth small, fringe-like ....*Gillicus*

Ichthyodectes comprises at least nine species, all from the Niobrara Cretaceous of Kansas. Eight of these species were described by Cope and one by O. P. Hay under the following names: *I. anaides* Cope, *I. ctenodon* Cope, *I. hamatus* Cope, *I. prognathus* Cope, *I. perniciosus* Cope and *I. cruentus* Hay. Gove and Logan Counties have produced most of the specimens of *Ichthyodectes* so far recovered. The teeth in this genus are moderately small, all of equal length, hollow, and not at all compressed. Other species occur in the Cretaceous of Mt. Lebanon, in Asia Minor, and of England.

The genus *Gillicus,* with its sickle-shaped maxilla, may be distinguished from *Xiphactinus* by its much smaller size and the character of its teeth; from *Ichthyodectes,* it is distinguished by the relatively smaller size of its mouth (1/2 to 1/3 smaller), and by its dentaries which are very short but of great depth. In total length, this genus is about four feet or a little more. *Ichthyodectes* is somewhat larger, reaching six feet or more. *Gillicus arcuatus,* described by O. P. Hay, from a Niobrara Cretaceous deposit on the "bank of the Solomon river," is the only recorded species from Kansas.

The family *Saurodontidae* is closely related to the *Ichthyodectidae* but may be distinguished by the form of its teeth, which consist of a single row in each jaw of *compressed cutting teeth.* Foramina or notches are present below the border of the alveoli on the inner side of the jaw; a predentary bone is present but is toothless. The *Ichthyodectidae,* on the other hand, have a single row of *cylindrical* teeth in each jaw; there are no foramina nor notches below the border of the alveoli; the predentary is absent. In both families the skull is laterally compressed. Two genera belonging to this family of the *Saurodontidae,* namely *Saurodon* and *Saurocephalus,* have been recorded from Kansas. The first has deep notches below the alveolar border on the inner side of the jaw and its teeth have almost cylindrical crowns; the second has foramina below the alveolar border on the inner side of the jaw, but its teeth have short, compressed crowns. Four species of *Saurodon* have been recorded from the Niobrara Cretaceous of western Kansas, namely: *S. phlebotomus* Cope, *S. broadheadi* Stewart, *S. xiphirostris* Stewart and *S. ferox* Stewart.

Of the very similar genus, *Saurocephalus,* three species are on record from the Niobrara Cretaceous of western Kansas, namely: *S. arapahovius* Cope, *S. dentatus* Stewart and *S. pamphagus* Hay. Cope's species was described from such fragmentary material that it can hardly be recognized. It may possibly be a synonym of *Saurocephalus lanciformis* Harlan, recorded from "Cretaceous, Missouri River." The distinguishing features of all the species of both *Saurodon* and *Saurocephalus* are too technical to be of value here. They were predaceous forms rivaling the *Ichthyodectidae* in fierceness and, while anatomically better known from Kansas than elsewhere, it is nevertheless interesting to note that they occur in the Lower Cretaceous of Switzerland, the Eocene of Egypt, and the Miocene of Austria—all identifications based mostly upon the teeth. *Saurodon* occurs also in the English Chalk.

The family *Stratodontidae* has a depressed skull with its top beautifully sculptured; the jaws have one or more series of conical teeth firmly ankylosed to the bone, and *not set in sockets.* The genera *Stratodus* and *Cimolichthys* occur in Kansas, the former with a short premaxillary with several rows of teeth; the latter with a long premaxillary with very small teeth in one row.

The species of *Stratodus* recorded from the Niobrara Cretaceous of western Kansas are but two: *S. apicalis* Cope and *S. oxypogon* Cope. These are rather large, slender fishes, evidently predaceous, and notable for the very large size of certain of the teeth on the palatines and ectopterygoids, in the roof of the mouth.

The genus *Cimolichthys* Leidy has been reported from the Upper Cretaceous of England, France, Egypt and Kansas. In this genus the palatines carry two longitudinal rows of large teeth; the dentary has a few large and many small teeth. Large plates of dermal bone extend from the occiput along the middle of the back to the dorsal fin, while a similar row of smaller plates carries the lateral line. Five species are recorded from Kansas, four from the Niobrara Cretaceous and one from the Fort Pierre: *C. nepaeolica* Cope, *C. semianceps* Cope, *C. contracta* Cope, *C. merrilli* Cope and *C. lisbonensis* Stewart. *Cimolichthys semianceps* is from Graham County; *C. lisbonensis,* from the Fort Pierre of Logan County; county records are not available on the others. The skull of *C. nepaeolica* is ten inches long and over five inches broad just behind the orbits of the eyes.

The family *Enchodontidae* is evidently rather closely related to the *Stratodontidae.* Although in size the different species of *Enchodus* vary from only a few inches (six or less) to about seven feet in length, the form is rather constant, the body being elongate fusiform and the head triangular in profile. Both head and body are laterally compressed. There are two longitudinal ridges on the roof of the skull with a shallow median depression between them. Otherwise the head is quite flat above. The museum of the University of Kansas contains what is probably the best and most extensive material of this genus to be found in any museum in the world.

Enchodus has been described by Loomis as both a deep and a shallow water fish; however, since its bones were loosely articulated and seldom found in proper association, it would seem that more deep-water specimens, than shallow, have been collected. In the mouth the palatines usually bear a single large tooth, while the dentary has an inner row of large teeth, and usually an outer fringe

of smaller ones. On all the tooth-bearing bones in the roof of the mouth the teeth stand on pedestal-like elevations, or else they are pleurodont, *i.e.*, adherent to the side of the dentary bone. The maxilla sometimes takes part in the formation of the upper margin of the mouth. The parietals are separated by the supraoccipitals; the squamosal is small; the pterotic is present. The fin-rays are jointed. The scales are cycloid, small or absent. Some of the genera in this family have longitudinal rows of large bony dermal plates along the mid-dorsal and lateral lines.

The *Enchodontidae* are extinct predaceous fishes, possibly with living relatives in the abyss today. It seems probable that the only member of this family ever to have lived in Kansas was *Enchodus* itself which occurs in the Niobrara Cretaceous. Other genera are known from the Upper Cretaceous of Syria and Europe. The remains of *Enchodus,* though usually in very fragmentary condition, occur everywhere throughout the Kansas Niobrara. Thirteen species have been listed by Stewart, but it is by no means sure that all will prove valid when better material for study comes to light. These are: *Enchodus petrosus* Cope, *E. shumardi* Leidy, *E. dirus* Leidy, *E. dolichus* Cope, *E. parvus* Stewart, *E. amicrodus* Stewart, *E. calliodon* Cope, *E. gladiolus* Cope, *E. carinatus* Cope, *E. anceps* Cope, *E. semistriatus* Marsh, *E. minimus* Stewart, and one listed but not named by Stewart.

Little of a general nature can be said about these Kansas species, since in almost all cases there is little known of their skeleton except the palatines and mandibles. The additional points given above are based on examination of Old World species.

The family *Osteoglossidae* has a depressed skull that is beautifully sculptured. The maxilla, premaxilla and dentaries carry many rows of minute teeth. The suboperculum is reduced. The fins are without fulcra; the scales without ganoine. The supraoccipital is separated from the frontals by the parietals; there is no adipose fin. The pelvic fins have no more than seven rays. The maxilla is firmly attached to the posterior end of the premaxilla. The premaxillae are paired. The ribs are inserted on the parapophyses.

To this family there has been assigned but one genus, *Anogmius,* in Kansas; it comes from the Niobrara Cretaceous, and has four recognized species, namely: *Anogmius contractus* Cope, *A. aratus* Cope, *A. evolutus* Cope and *A. polymicrodus* Stewart.

Anogmius has unpaired bony masticating plates upon the parasphenoid and correspondingly upon the glossohyal between the

branchiostegal bars, which rub against each other and are covered with small grooves. The caudal fin is deeply notched; the fin-rays are not jointed. The vertebrae at the end of the vertebral column are shortened and pressed closely together; a hypural is present; the dorsal fin is long.

Plethodus Cope with its premaxillae and ethmoid coossified; with only one masticating plate, and that the lower, is related to *Anogmius* and likewise comes from the Upper Cretaceous of Kansas. It also occurs in the Upper Cretaceous of Egypt and the middle Upper Cretaceous of England.

The family *Salmonidae* is so well-known from its living representatives that it is interesting to note that no less than eight species, all of the genus *Pachyrhizodus,* have been recorded from the Niobrara Cretaceous of Kansas, namely: *Pachyrhizodus kingi* Cope, *P. latimentum* Cope, *P. sheari* Cope, *P. caninus* Cope, *P. leptopsis* Cope, *P. leptognathus* Stewart, *P. velox* Stewart, and *P. minimus* Stewart.

In *Pachyrhizodus* the large conical teeth, compact and sturdy, are ankylosed to the margin of the jaw and not set in sockets, but on the outer flange of the jaw-bone, *i.e.,* they are *pleurodont.* The vertebral centra are short. There are three stout suborbital plates, behind and below the orbit. The squamosal is united with the parietals by means of a suture. The opercular mechanism comprises 20-30 dermal gill filaments. There is a gular plate between the mandibles. The dorsal fin is short and situated almost at the middle point of the body; there is no evidence of an adipose fin in the fossil species. The imbricating cycloid scales are thin.

This genus occurs in the Upper Cretaceous of Europe as well as of North America. Although, owing to the fragmentary condition of the remains, there is some doubt that *Pachyrhizodus* is really a salmon, there does not appear to be any other family to which it can be referred, unless one were to erect the family *Pachyrhizodontidae* for it alone.

The family of the herrings, the *Clupeidae,* in so far as its fossil representatives are concerned, is often so similar to the *Salmonidae,* that it is very difficult in some cases to decide to which of the two families a new specimen belongs. The genus *Leptichthys* is one of these difficult cases and in consequence has been variously allocated in the past. On the whole, however, it would appear to be a *herring* rather than a *salmon,* so we assign it to the *Clupeidae.*

The *Clupeidae* are slender fishes with cycloid scales; the vertebral centra are solid, *i.e.*, not perforated for the passage of the notochord; the abdominal vertebrae have short transverse processes. The dorsal fin is short, in the middle of the back, and there is no adipose fin. The supraoccipital separates the parietals; the upper margin of the mouth cavity is formed by the premaxillae and maxillae. The teeth are small, sharp-pointed, and more seldom absent. The most marked distinction from the *Salmonidae* is the absence of the adipose fin.

In *Leptichthys* the body is elliptical in shape and covered with large, thin cycloid scales in ten or twelve rows. The skull is rather bluntly pointed in front. The short dentaries are turned upward in front and carry sharp-pointed teeth. The pectoral fins have at least fourteen rays—the first two or three of which are cross-segmented, while the rest are longitudinally split. The pelvic fins are abdominal and none of their rays are cross-segmented. The dorsal fin is composed of twelve or more short bony rays. The one species from Kansas is *Leptichthys agilis* Stewart, which is about one foot in length. One can imagine them going in huge schools like the living herring, and they were doubtless relished as a "food-fish" by *Clidastes* and other aquatic reptiles that shared the Cretaceous sea with them.

The family *Dercetidae* is represented by fishes in which the body was not covered with scales, but rather with several rows of bony keeled plates or scutes. The teeth were in a single series on the margin of the jaws. The upper margin of the mouth cavity was composed entirely of the premaxillae. The supraoccipital did not separate the parietals. The squamosal was well developed and the unpaired fins were distinct from one another.

Only one genus and species has been recorded from the Niobrara Cretaceous of Kansas, namely, *Leptecodon rectus* Williston. This is a long, slender species with the sides of the body covered by five rows of large, firmly united scutes, each one keeled. The teeth are numerous, small, pointed and slender. The pectoral fins are small, of seven or eight rays. The pelvic fins are very small and are located at about the mid-length of the body and tail. The caudal fin is small, its rays feeble. Other fins are unknown. The length of this fish is about ten inches. Williston pointed out its "curious resemblance to the Pipe fishes."

Another family of the Cretaceous teleosts represented in Kansas is that of the *Mugilidae,* or mullets, in which the maxillary has

no part in forming the upper margin of the mouth. The dentaries are short and without teeth. Elsewhere the dentition is feeble or absent. The body is rather elongate, compressed, and covered with large or medium-sized cycloid scales. The pectoral fins are inserted high up and are supported by one spine and five rays. There are two dorsal fins set wide apart; the pelvic fins more or less approximate to the pectorals. This family includes the genus *Syllaemus,* the only mugilid genus heretofore reported from Kansas, and it only doubtfully. Cope assigned it to this family, but Jordan considered this "an arrangement quite impossible." So, apparently more or less in despair of doing anything better, he erected the family *Syllaemidae* to include not only *Syllaemus latifrons* Cope, but also *Apsopelix sauriformis* Cope and *Leptichthys agilis* Stewart.

Syllaemus latifrons Cope is recorded from the "Fort Benton Cretaceous" but the exact locality is not known. It is a fish about fourteen to fifteen inches long, popularly known as the "fence-post fish," since it is sometimes found while splitting the "Benton" limestone to make fence posts. Some of the *natural casts* of these fishes are very accurate representations of the superficial characters of this species, though much remains to be learned about its internal anatomy or even of the skeleton or skull.

Jordan, in 1924, set up a new family of teleost fishes to include five new species from the Kansas Niobrara Cretaceous. The type specimens had been collected by the late H. T. Martin, for many years in charge of the paleontological museum of the University of Kansas. Jordan calls his new family the *Niobraridae,* of which a new genus, *Niobrara,* was made the genotype. Jordan describes this genus as follows:

"Body elliptical in form, compressed, tapering to a very slender caudal peduncle, which bears a long and deeply forked caudal fin; mouth moderate, with short jaws, the teeth apparently small, in one or two rows; scales large, smooth; vertebrae about 52, each deeper than long, much constricted, and with three shallow ridges and furrows; basic bones of the caudal fulcra decussating across the last vertebrae and the hypural. Dorsal fin many-rayed, beginning not far from the head, elevated in front; anal fin obliterated, its interspinals beginning at end of body-cavity, before tip of ventrals, the fin no doubt many rayed; body cavity one-fourth longer than head; ventrals strong, inserted midway between middle of head and base of caudal; pectoral long, inserted high on the sides; caudal

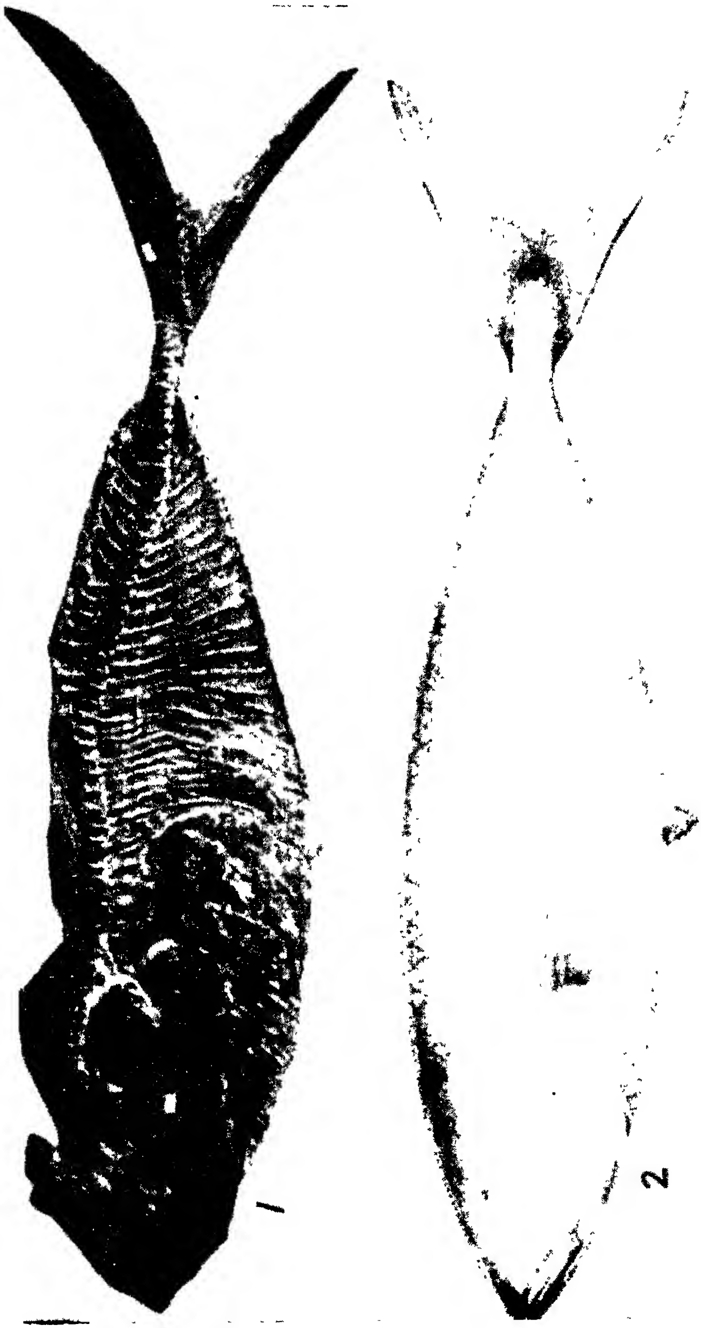

PLATE 5.—Zanclites. (1) shows the form of the fossil as found which was some twenty-one and a half inches in length, and (2) gives the artist's restoration of the fish. The plate is reproduced from a paper by the famous ichthyologist, David Starr Jordan in the *University of Kansas Science Bulletin*, 1924.

widely forked, its rays relatively few and strong, much branched at tip, with few fulcra."

One species, *Niobrara encarsia* Jordan, form the Niobrara Cretaceous of Trego County, Kansas. The type, No. 179 in the K. U. Museum of Vertebrate Paleontology, is a fine large fish about 27 inches long.

A second genus *Zanclites,* (Plate 5) is established by Jordan and assigned to the same family, *Niobraridae,* with *Zanclites xenurus* Jordan as the type species. The type specimen (No. 52, K. U. Mus. Vert. Paleo.) is from the Niobrara Cretaceous of Gove County, Kansas. It is a fine, well preserved specimen about 21½ inches long. It is clearly closely related to *Niobrara,* "differing mainly in the small weak ventrals, the short, broad pectoral, the caudal equally deeply forked, but with many more rays and these curiously recurved. It may lack the elevated dorsal of *Niobrara,* but this is not certain." (Jordan.)

A third genus, *Kansanus,* was set up by Jordan to receive the species which he calls *Kansanus martini,* from the Niobrara Cretaceous of Gove County, Kansas. The type (No. 128, K. U. Mus. Vert. Paleo.) consists of the head and shoulders only of a large fish, "which is allied to *Niobrara* and *Zanclites,* with which it agrees in general form and in the large, thin, cycloid scales, roughened somewhat, however, along the concentric striae. It differs in the much larger mouth, the cleft half the length of the head, and stronger teeth in four rows, as also in the long, pointed pectoral fin, which is two-thirds the length of the head." (Jordan.)

Another new genus and species was named *Luxilites striolatus* by Jordan. It is based on the head alone of a fish and "is distinguished by the small even teeth in its large mouth; by the large, deep, closely imbricated scales, suggesting those of the cyprinoid genus *Luxilus,* by the fine striation of its scales, by the coarser striation of most bones of the head; the presence of rough tubercles, resembling small scales, on the skin between the opercle and the subopercle and between the uppermost branchiostegals. Pectoral narrow, without greatly enlarged rays, inserted high, opposite lower part of opercle" (Jordan). Although the relationship of this genus is not altogether clear, it would seem to belong close to *Kansanus* and *Niobrara.*

Still another new genus and species was called *Ferrifrons rugosus* by Jordan. "This genus seems to have much in common with *Niobrara,* differing in the hard casquelike covering of the head above

the bones; this with the exposed parts of the shoulder girdle everywhere roughened with fine, blunt points or irregularly vermiculated striae and in the low insertion of the pectorals. The body is very deep and compressed, tapering rapidly backwards to a stoutish tail, which bears a long, widely forked caudal somewhat like that of *Niobrara*. The scales are moderate, thickened, roundish, and with the surface rough with small points. The pectoral and ventral fins are moderate in size, the dorsal and anal apparently many-rayed, the rays probably slenderer, the dorsal beginning over middle of head. The low insertion of the pectoral fin in this genus, common to most physostomous fishes, separates it rather sharply from the *Niobraridae,* but I know of no other place for it. The bony casque suggests certain living *Osteoglossidae,* which, however, *Ferrifrons* resembles in no other respects." (Jordan.)

This is a large fish about 24½ inches long, from the Niobrara Cretaceous of Gove County, Kansas. It is No. 296 in the University of Kansas Museum of Vertebrate Paleontology.

The family *Phareodontidae* is represented by a new genus and species which Jordan calls *Eurychir lindleyi.* He remarks that "this genus seems closely allied to *Phareodus* Leidy, differing in the larger mouth, smaller and more wide-set teeth, and in the enormous development of the first ray of the pectoral fin."

Tertiary fishes have been more rarely described from Kansas than have Mesozoic species. Hibbard, in 1936, described two new sunfishes of the family *Centrarchidae* from the Middle Pliocene of this state. The types of both species are from the diatomaceous marl bed, Middle Pliocene of Logan County. Both seem so closely related to living genera, that it seemed "advisable at present to refer . . . [them] . . . to living genera, since many of the characters by which our modern genera are distinguished are those not found preserved in fossil forms, . . . [and] . . . because they have certain skeletal characters in common." (Hibbard.)

The first of these is *Chaenobryttus kansasensis* (Holotype No. 792F, University of Kansas Museum of Vertebrate Paleontology), while the second is *Pomoxis lanei* (Holotype No. 789F, K. U. M. V. P.). The length of *C. kansasensis,* without the tail is 94 mm., while that of *P. lanei* is 70 mm.; however, the latter seems to be an immature specimen.

In *Pomoxis* (Plate 6) the dorsal fin is scarcely larger than the anal; gill rakers are very long and slender; the spinous dorsal is shorter than the soft, with 6 to 8 spines; anal spines 6. In *Chaenob-*

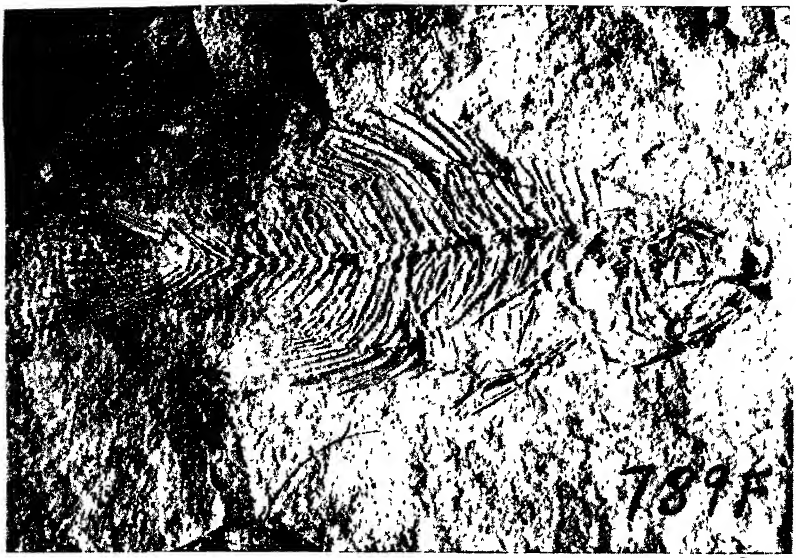

PLATE 6.—Pomoxis. This small fish (the fossil is shown at approximately life size) was originally described by Hibbard. *University of Kansas Science Bulletin,* 1936. The specimen is in Dyche Museum.

ryttus, the dorsal fin is much larger than the anal; gill rakers are shorter; the body is comparatively short and steep, the depth usually more than 2/5 the length; dorsal fin not deeply divided; the tongue and pterygoids carry teeth; the mouth is large (the maxillary reaching past the middle of the eye); the scales are ctenoid; the caudal fin concave behind; the opercle ends in a convex process or flap; anal spines 3.

The *Amiuridae,* or catfishes, are known throughout the Pliocene and Pleistocene, and are represented in Kansas by pectoral spines of at least two genera and one complete skeleton associated with the sunfishes just referred to. These were collected by Hibbard and Dunkle and have not yet been described.

The family *Cyprinodontidae* includes only small or very small fishes, rarely reaching a foot in length. They occur in fresh or brackish waters and may be divided into two groups on the basis of their food requirements; some are carnivorous with a short digestive tract, others are plant eaters and have a long, much coiled digestive canal. The head is flat with a moderate sized protractile mouth in a moderately long snout. The margin of the oral opening is formed above by the premaxillaries only. The teeth are set in a narrow band on the jaws, the outer rows being the largest and conical in form.

Plate 7.—Fundulus. Another fossil fish, now in Dyche Museum, the fossil itself being 2¾ inches in length. The plate is from the paper by Hibbard and Dunkle, Bulletin 41, State Geological Survey, 1942.

The pelvic fins have five to seven rays, or are absent; the dorsal fin with thirteen rays arises well back in front of or opposite the origin of the anal fin; there is no dorsal adipose fin. The air-bladder may

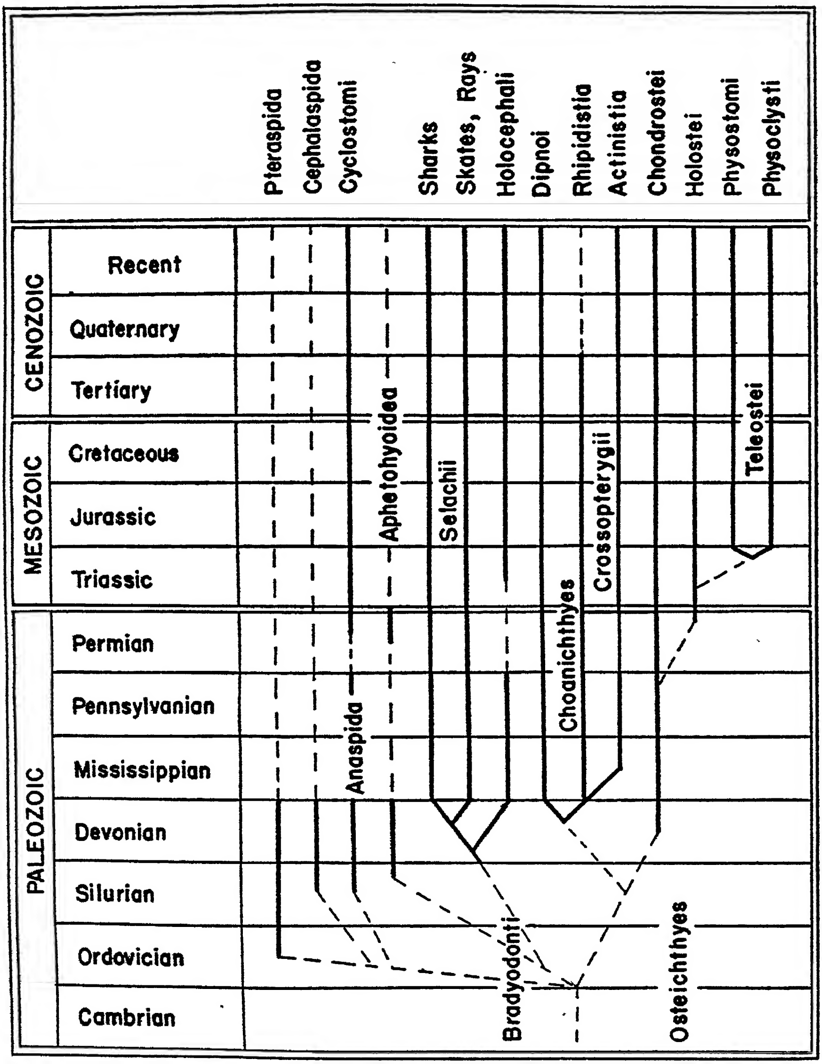

FIG. B.—GEOLOGICAL DISTRIBUTION OF FISHES

Solid lines indicate known distribution in time; broken lines above the Devonian indicate absence in time; below the Devonian, broken lines show hypothetical relationships. For the inter-relations of the various classes and sub-classes, etc., of fossil fishes compare with the table showing the classification of fishes on page 136.

or may not be present, but in no case connects with the throat by an open tube. The sexes are alike.

The members of this family are familiarly known as "killifishes" and comprise about two hundred known species, mostly from America, only about thirty being recorded from southern Europe, southern Asia, Japan and Africa. The genus *Fundulus* is represented by numerous specimens in the collection of the Museum of Vertebrate Paleontology of the University of Kansas, all from the diatomaceous marl deposit, middle Pliocene beds of the Ogallala formation of Logan County, Kansas. The type of a new species (K. U. M. V. P., No. 848F) was described by Hibbard and Dunkle under the name *Fundulus detillae* (Plate 7). This is a small moderately elongated fish that was found associated with the two species of sunfishes listed above, and with a fossil spade-foot toad, *Scaphiopus studeri,* described by Dr. E. H. Taylor. *Fundulus sternbergi* has been described by George M. Robertson from northwestern Logan County. The type (No. 26) was collected by George F. Sternberg of the Fort Hays College Museum.

Summary

To summarize the relations between the various groups of fish and the geologic time periods in which they occurred, Fig. B, has been prepared. Note that the diagram suggests a common ancestral fish in the Cambrian. Note, too, that a solid line extending through the Recent, indicates that fish forms occurring in past geologic time are still in existence at the present day.

Glossary

The following terms used in this paper are here explained for the benefit of those readers who may not be familiar with biological or geological terms.

Alveolar: pertaining to the socket for a tooth; from *alveolus,* a small cavity or cell, as the socket for a tooth.

Biserial: consisting of or arranged in two series or rows; in the case of fins of fishes, consisting of two rows of rays lying alongside the bony axis of the fin.

Cartilaginous: gristly; consisting of cartilage; a tough, elastic animal tissue consisting of numerous cells surrounded by a solid, gelatinous matrix.

Caudal: of, pertaining to, or near the tail of an animal; from the Latin *cauda,* a tail.

Centrum: the body of a vertebra or segment of the backbone; plural, *centra.*

Chiasma: in anatomy, the intercrossing and intersecting of the fibers of the optic nerves.

Cornified: converted into horn; from the Latin *cornu,* horn.

Cosmoid: made of or including cosmine in its structure. Cosmine is a substance resembling the dentine of a tooth. (See explanation on page 148 of this paper).

Crinoid: a relative of a star-fish, having jointed stems and radial arms; also known as a sea-lily.
Ctenoid: having a toothed or comb-like margin; from the Greek *ktes* (*ktenes*), a comb. Specifically applied to the scales of fishes where the posterior margin is toothed.
Cusp: a prominence or protuberance on the crown of a tooth.
Dermal: pertaining to, or derived from the skin (Latin *derma,* skin).
Distal: situated away from the center of the body or the point of attachment; the opposite of *proximal*: thus, the nails are at the *distal* ends of the fingers.
Dorsal: of, pertaining to, on, or near the back, as the dorsal fin of a fish; from the Latin *dorsum,* the back.
Endoskeletal: of or pertaining to the internal bony framework of the body; the opposite of *exoskeletal,* which see.
Epichordal: situated above the caudal end of the notochord or back-bone, as in the tail of certain fishes.
Exoskeleton: any structure produced by the hardening of the skin, such as hair, feathers, claws, horns, hoofs, or bone, *e.g.*, the scales or plates of fishes, or the bony armor of a turtle.
Foramen: a hole or opening; an orifice in a bone for the passage of a nerve or blood-vessel. (Plural *foramina*).
Fusiform: tapering from the middle toward each end; from the Latin, *fusus,* a spindle.
Ganoid: having an enamel-like appearance, as the scales of certain fishes; from the Greek *ganos,* brightness, and *oid,* like.
Ganoine: the dense bony tissue which gives the enamel-like luster and transparency to the plates or scales of certain fishes.
Heterocercal: having an unequally divided tail or tail-fin; with lower part of the tail fin the larger.
Holotype: a particular *individual* selected as the type of the species, or the *only specimen known* at the time of the publication of the description of the species.
Homocercal: having the tail fin symmetrical as to its upper and lower halves; opposed to *heterocercal.*
Hyoid: the bone or cartilage developed in the second gill arch back of the mouth; so called because it has a shape resembling the Greek letter *upsilon;* roughly, Y-shaped.
Hyoidean: pertaining to the hyoid bone or cartilage; like the Y-shaped or horse-shoe shaped arch forming the bony base of the tongue in man.
Hyomandibular: pertaining to that bone in fishes which supports the lower jaw and articulates with the skull; the upper element of the hyoid arch.
Imbricating: lying one over the other like the shingles of a roof.
Lamella: a thin plate or layer; plural, *lamellae.*
Mandibular: of, or pertaining to, the mandible, or lower jaw.
Nares: the nostrils; the external or internal openings of the nose
Notochord: the fibrocellular or cartilaginous rod-like structure which is developed in all vertebrates as the basis of the later development of the backbone.
Orbit: the cavity of the skull that contains the eye; the eye-socket.
Osseous: bony; made of bone; having the nature or structure of bone.
Parietals: a pair of bones, developed from the skin, forming a part of the top and sides of the skull. (From Latin, *paries,* wall.)
Pectoral. of, pertaining to, or connected with the breast or chest; thoracic: as a pectoral limb or fin.
Phyllospondylous: of or pertaining to a group of extinct amphibians with a persistent notochord inclosed in barrel-shaped vertebrae. (From the Greek *phyllon,* leaf, and *spondylos,* vertebra.)
Placoid: plate-like; shaped like a plaque.
Pterotic: of or pertaining to one of the bones enclosing the internal ear; one of several bones around the internal ear.
Rhipidistian: Of or pertaining to the Rhipidistia, a group of fishes having special supports to the fins.

Rostrum: the snout or elongated muzzle of an animal; in sharks, the part of the face projecting in front of the mouth.

Spiracle: an opening on the upper side of the head in many fishes suggestive of a nostril or breathing aperture, but ending blindly and having no part in respiration.

Squamosal: a thin, scale-like membrane bone in the side of the skull, with which, in mammals, the lower jaw articulates.

Suborbital: a bone situated below the orbit of the eye or on the floor of the orbit.

Tetrapod: four-footed; quadruped. (Greek, *tetrapous,* four-footed.)

Type or *Type Specimen*: an individual animal, or any part of one, prepared and preserved, from which the description of the species has been prepared and upon which the specific name has been based. Type specimens have a particular value in descriptive zoology comparable to the authoritative standard in any system of weights, measures, or coinage. When available for examination, they take precedence over any published description or figure, and are conclusive evidence in cases of doubtful or disputed specific identity.

Unossified: not bony.

Visceral: of or pertaining to the viscera, or internal organs, more particularly, to those in the body-cavity.

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The Editor's Page

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VOL. 47, NO. 2 DECEMBER, 1944

ROBERT TAFT, *Editor*

This issue should reach Academy members during the holiday season and the editor, doubtless like many other editors, is racking his brain for an appropriate holiday greeting. The best that I can do is to wish our valiant ones in the armed forces the best of good fortune and to each and every Academy member good health and some measure of good cheer for the tasks that lie ahead. More fulsome wishes seem impossible at a time when it is doubtful if, in the history of civilized man, we have ever been further removed from an era of peace and goodwill toward men.

A review of events since 1941, however, appears to indicate that we have weathered and largely recovered from the appalling disaster of Pearl Harbor; further, there is some faint hope that the end of part of the bloodshed may be in sight. Our ability to make this recovery and progress is in itself a sign of hope; if we can surmount one terrible disaster we should be able to surmount the difficulties of peace.

There should be apparent to us, the scientific profession, at least two major lessons from the social cataclasm now taking place. In the first place we never again should become so engrossed with our own affairs that the affairs of state and nation are neglected. The giant intellects to whom we have previously consigned our interests in these matters have been able to bring us little but war and bloodshed. It is now up to us and all other common men to exercise our brains and voices so that peace and goodwill become more nearly a reality.

The second lesson that should be brought home to us is one that I previously voiced in the foreword of *Science and the War,* published by the Academy last summer. I made there a statement to the effect that science, in the form of concentrated, large-scale investigations, is one of the most powerful—if not the most powerful—tool of war; but scientific endeavor, applied with the same vigor and concentration and on the same scale that it has been applied to war, can be still more valuable in the affairs of peace. Imagine

the tremendous strides that could be made in conquering man's ills and in adding to his comfort, enjoyment and understanding of life if competent specialists were trained in many fields, utilized in carefully mapped programs, and granted funds for the prosecution of their tasks on a scale even partially approaching the astronomic sums now being expended for the destruction of man. It is apparent from these two lessons that we can no longer be scientists alone; we must be missionaries of a new order.

* * *

The new form of the *Transactions* appears to have met with the approval of a considerable number of Academy members. All the notes and letters received by the editor have been enthusiastic about the change, and the agreement seems to be that we now have a livelier and more readable journal; a gain obtained without sacrificing the primary purpose of our publication.

If, by chance, the second quarterly is read by those who missed the first one, a description of the changes in editorial policy will be found on page seven of the September (1944) issue.

That the new form is arousing interest can be seen in more tangible form from the fact that 26 new members from the University of Kansas alone have been secured after examining our first quarterly issue. The membership committee of the Academy might take notice.

* * *

Our feature article in the present issue, by Dr. H. H. Lane, professor of zoology at the University of Kansas, should appeal to all the scientific profession in the state. There has been no previously published review in this field so that the article should be not only of general interest but should have lasting scientific importance as well.

Dr. Lane, Dr. Henry Higgins Lane to be more specific, was born in Indiana and educated in part in two Indiana institutions, Depauw and the University of Indiana. His formal education was completed with a doctorate from Princeton. His teaching experience includes intervals at Hiram College, the University of Oklahoma, Phillips University and the University of Kansas. Of these institutions, he has served the University of Ok-

DR. H. H. LANE

lahoma (1906-1920) and the University of Kansas longest. He has been at Kansas, serving

as head of the department of zoology from 1922 to 1944 and as director of museums from 1935 to 1944, retiring from administrative duties on July first of the current year. The restoration and remodeling of the well-known Dyche Museum which took place in 1941 were all done according to Dr. Lane's plans and under his direction. Vertebrate paleontology, as the story which follows shows, has long been one of his main interests. He is also the author of the widely used text book *Animal Biology* and a book of wide appeal *Evolution and the Christian Faith.* Our neighbors to the south will recall Dr. Lane as the first president of the Oklahoma Academy of Science when it was organized in 1909; another tie of common interest which should bind these two sister institutions.

The editor's acquaintance with Professor Lane dates back for more years than he now can believe possible. To be specific, my first recollection of Dr. Lane occurred a third of a century ago when as a high school boy, I served as a stage hand in the one and only opera house at Norman, Oklahoma, the site of the University of Oklahoma. One of the productions offered when the editor was a member of the opera house "staff" was the annual senior play of the University. I have forgotten the name and most of the details of the play but one incident I do remember. The hero of the play was making love—or attempting to—to the heroine in a front corner of the stage but was being continually interrupted by "occurrences" toward the back of the stage. One of the occurrences was the intrusion of an individual in natty attire — including a pith helmet—who appeared from the wings and every few steps stopped to peer at the ground through a lens. The exasperated hero asked the heroine with some heat "Now who is *that?*" "Oh, that's Professor Lane," was the reply. "Someone left his stable door open last night and his bob-tailed eohippus got out. He's trying to trail him by his three-toed tracks."

Which shows that Professor Lane has been on the trail of the eohippus and kindred beasts for lo, these many years. We predict that the review on our ancient animals will find a large audience and increase the reputation of both the author and the *Transactions.*

* * *

The familiar "Kansas Botanical Notes" by Dr. F. C. Gates appears in this issue as they have now for over twenty years in the *Transactions.* Dr. Gates started his botanical notes in 1923 and has given them at every meeting since that date; a record which the editor is sure surpasses that of any other contributor. Collectively, the notes constitute a portion of a real natural history of the state. We should have more of this type of record. In the past, Professor Agrelius of Emporia published many of his yearly botanical notes; for some years, Kansas mycological notes may be found in the *Transactions* and Professor Roger Smith in collaboration with others, has published a number of annual insect population records in our past volumes. These systematic

and concise annual summaries should serve as incentives and suggestions for other members of the Academy.

* * *

Special attention should be directed to the article by Miss Dorothea Franzen on page 261. The expense involved in the study of mollusca made by Miss Franzen was paid for in part by an Academy research award. If an Academy award can aid and stimulate in the production of the careful type of work shown in Miss Franzen's study, we should, if possible, have more Academy awards.

* * *

Chemists have always taken unaccountable satisfaction in using inordinately long words and in employing a complex nomenclature. After reading the paper on the Troy skull by Drs. Eiseley and Asling (page 241), the editor is willing to pass the honor of possessing the most extraordinary nomenclature on to the anthropologists. Read it, chemists, and be humble; or at least be humbler.

* * *

But we all—including chemists—can afford to be humbler on occasion. (I am here using *humble* in the sense of unassuming or not arrogant.) Although we may regard the scientific method and the pursuit of scientific knowledge as *the* way of life—and any member of the profession who doesn't so regard it is out of place—we should remember that there are other ways of regarding the objects and the phenomena with which our sciences deal. Our way is only one way; a fact which we sometimes forget. For instance, the late Vachel Lindsay once wrote:

"There's machinery in the butterfly.
There's a mainspring to the bee.
There's hydraulics to a daisy
And contraptions to a tree.

"If we could see the birdie
That makes the chirping sound
With psycho-analytic eyes,
And x-ray, scientific eyes,
We could see the wheels go round."

And I hope all men
Who think like this
Will soon lie
Underground."

* * *

Our program for future review articles is beginning to take form. Definitely promised are the following articles:

Two, and possibly three, additional parts of "A Review of Kansas Vertebrate Fossils" by Dr. H. H. Lane as mentioned on page 129;

"The Geography of Kansas" by Associate Editor W. H. Schoewe;

"The Colorado Desert of California: Its Geological History and Present Fauna and Flora" by Dr. T. D. A. Cockerell;

"The Salt Industry of Kansas" by the Editor.

"The Development of the State Conservation Agency in Kansas" by Dr. E. O. Stene, University of Kansas;

"The Discovery and Characteristics of the Ninth Planet" by Mr. Clyde W. Tombaugh, Lowell Observatory, Flagstaff, Arizona;

"The Mellon Institute of Industrial Research: Its Organization and Accomplishments" by Dr. E. R. Weidlein, Director,

The Mellon Institute, Pittsburgh, Pa.

In addition we have tentative promises for a number of articles including:

"A Review of Kansas Weather" by S. D. Flora, U. S. Meteorologist for Kansas;

"Sleep Producing Drugs" by Dean J. Allen Reese of the University of Kansas School of Pharmacy;

"The Milling Industry of Kansas" by Dr. E. G. Bayfield of Kansas State College, Manhattan.

Correspondence with other individuals, some of whom have wide reputations in their fields, indicates the possibility of including other interesting topics in the *Transactions*. However, the editor re-extends his invitation for all Academy members to suggest additional topics and authors for this valuable feature of our journal.

* * *

LETTERS TO THE EDITOR

Cambridge, Mass.
November 8, 1944

Mr. Editor:

In my presidential address appearing in the September, 1944, issue of the *Transactions*, will you please publish the following correction. In the description of the major telescopic equipment of the United States Naval Observatory at Washington given on page 28, I mentioned "a 40-inch Ritchey-Chretien aplanatic refractor." This statement should read "a 40-inch Ritchey-Chretien aplanatic reflector." Thank you greatly for publishing the correction.

Harvey A. Zinszer.

* * *

When I contemplate the immense advances in science and discoveries in arts which have been made within the period of my life, I look forward with confidence to equal advances by the present generation, and have no doubt they will consequently be as much wiser than we have been as we than our fathers were, and they than the burners of witches. —Thomas Jefferson in a letter to a friend, March 3, 1818.

Scientific News and Notes of Academy Interest

Saturday, April 14, 1945, has been selected by the Academy Council as the date of our seventy-seventh annual meeting to be held at Manhattan. Mark your calendar so that no conflicting dates will be made—and plan now to be present.

The symposium published by the Academy last fall, *Science and the War*, attracted wide attention, not only in this country but abroad. Reviews were published in Canadian journals and on May 13, 1944, the well-known English journal of general science *Nature* devoted practi-

cally a whole column to its review. Within the past few weeks we have received a request for a copy from the Academy of Sciences of the Union of Socialist Soviet Republics in Moscow.

The position filled by the late Dr. J. W. Hershey, well known to older Academy members and formerly professor of chemistry at McPherson College, has been filled by Professor James M. Berkebile. Professor Berkebile is a graduate of Manchester College and of Ohio State University and for the past several years has been a chemist in the oil industry at Tulsa, Oklahoma.

Dr. Donald J. Ameel, secretary of the Academy, and assistant professor of zoology at Kansas State College, Manhattan, spent three months this past summer working for the Stream Conservation Commission of Michigan. He has now resumed his work at Kansas State College.

Dr. Winston Cram, professor of physics at Emporia State Teachers College is absent on leave to do research with the Sylvania Corporation, Flushing, New York.

Dr. E. V. McCollum of Johns Hopkins University, an honorary member of the Academy, was awarded, on Sept. 8 the Borden prize, a gold medal and $1,000.00, for his work on vitamins. Dr. McCollum donated his cash award to the University of Kansas to be used for the aid of students of chemistry. "During my undergraduate years [at the University of Kansas]" Dr. McCollum wrote the University, "I had to earn my own living and was always tired and sleepy. It would give me pleasure to know that the proceeds of this check enable one or more students to go to bed and get some sleep when they need it."

Dr. John W. Breukelman, president-elect of the Academy, and professor of biological science at Kansas State Teachers College of Emporia, has been made dean of the graduate school at the College, succeeding Dr. E. J. Brown, professor of education. Dr. Brown resigned his position at Emporia to become dean of the college at St. Louis University.

Dr. Loren Eiseley, associate professor of sociology in charge of courses in archeology and anthropology at the University of Kansas, has resigned his position to accept a position as head of the department of sociology at Oberlin College, Ohio.

Professor S. L. Loewen of Tabor College was employed during the past summer by the Wisconsin Conservation Department, Fisheries Division, Northeast Area, with headquarters at Woodruff, Wisconsin. Limnological surveys were made of "problem" lakes, particularly of the age, growth and parasites of fish.

Dr. Donald F. Hoffmeister has been recently appointed assistant professor of zoology and assistant curator of modern vertebrates at the University of Kansas. Dr. Hoffmeister comes to Kansas from the University of California.

Professor Frank U. G. Agre-

lius, past president of the Academy and associate professor of biological science at Emporia State Teachers College, has retired after a teaching service of 33 years to the College.

We are indebted to Mr. John M. Michener of Wichita High School East for calling our attention to the fact that the State Board of Education has announced that, beginning with the graduating class of 1946, all students of Kansas high schools must present for graduation at least one unit of a laboratory science (biology, physics, or chemistry). "In our case", writes Mr. Michener "this action will undoubtedly mean at least one more full-time teacher." The significance of this requirement should be called to the attention of the administrators of all high schools and colleges concerned.

Dr. W. H. Gray, associate professor of psychology at Emporia State Teachers College is on leave of absence for military duty. Capt. Gray was recently psychologist in the disciplinary barracks at Leavenworth.

Dr. C. W. Asling, assistant professor of anatomy at the University of Kansas, has been granted leave of absence beginning with the current semester to accept a research fellowship at the University of California.

Dr. W. D. Bemmels, professor of physics at Ottawa University, worked for some months this summer in the research division of the Curtis Wright plant at Buffalo, N. Y. He returned to Ottawa early in the fall.

Professor Lawrence Oncley, past president of the Academy and professor of chemistry at Southwestern College, has been on leave since June first and has been teaching in the Navy V-12 program at Duke University, Durham, North Carolina. Professor Oncley will return to Southwestern about December first.

Professor Clarence F. Gladfelter of Emporia State Teachers College has been granted leave of absence to direct the Kansas effort in the national milkweed collecting program.

Dr. Cora M. Downs, professor of bacteriology at the University of Kansas, is dividing her time between the University and a governmental research project at Frederick, Maryland. Dr. Downs commutes by plane about once a month between the University campus and Frederick.

Dr. Charles E. Burt, for many years professor of biology at Southwestern College, is resigning his position at the end of the current semester and will enter private business in Topeka.

The frame astronomy building and observatory of the University of Kansas, built originally in 1919, has been torn down. Dr. N. W. Storer hopes to move eventually to new quarters on the roof of the new mineral industries building, Lindley Hall.

Dr. J. W. Nagge, associate professor of psychology at Emporia State Teachers College, is on leave to the United States Army. Capt. Nagge was recently transferred to Fort Riley.

Dr. A. J. Mix, professor of botany and chairman of the department at the University of Kansas, has been granted leave of absence until next September to work for the U.S.D.A. in emergency plant disease prevention with headquarters at Newark, Delaware.

Professor T. L. Brenneman, professor of electrical engineering at Kansas State College, Manhattan, has been granted leave of absence to assist with the heavy load in the teaching of communications in the Navy V-12 program at the University of Kansas.

Dr. Donald Johnson, formerly of Fort Hays Kansas State College, is now a member of the psychology department of the University of Illinois.

Dr. L. Lieberman, assistant professor of physics at the University of Kansas, has been granted leave of absence to do research at a governmental war project at Woods Hole, Massachusetts.

Forrest D. Kellog, formerly acting head of the department of sociology at Southwestern University, Georgetown, Texas, succeeds Dr. Hiram C. Weld, assistant professor of psychology and philosophy at Baker University. Dr. Weld leaves his teaching position to become co-pastor of the Elm Park Methodist Church at Scranton, Pa.

Dr. J. C. Frazier, former secretary of the Academy, has recently published a brief article "The History of the Kansas Academy of Science." It will be found in the October (1944) issue of the *A.A.A.S. Bulletin*.

Mr. Earnest Boyce, professor of sanitary engineering at the University of Kansas, and engineer for the State Board of Health, who has been on leave since 1941 for military service, has resigned his position. He is now professor of municipal and sanitary engineering in the department of civil engineering at the University of Michigan. Mr. Boyce has been succeeded at the University of Kansas by Mr. Paul D. Haney who has been a member of the University staff and the State Board of Health since 1934.

Miss Ruth Hallett, who received her master's degree from Iowa State College in 1941, succeeds Mrs. Frances Wilson in the home economics department at Baker University. Mrs. Wilson has accepted a similar position at Stephens College, Columbia, Mo.

Dr. J. C. Willard of Kansas State College, Manhattan, and one of the veteran members of the Academy, has recently returned to his home after an operation at the local hospital. His many Academy friends will rejoice that he is making a satisfactory recovery.

Tabular Descriptions of Outcropping Rocks in Kansas (Bulletin 52, Part 4) by R. C. Moore, J. C. Frye, and J. M. Jewett, all members of the State Geological Survey, has recently (October, 1944) been published. The 76-page bulletin which contains nine figures, may be obtained by addressing the State Geological

Survey, Lawrence, Kansas, and enclosing ten cents for mailing charge. Fig. A of Professor Lane's review (page 132) appeared originally in the above bulletin and was kindly loaned us by the State Geological Survey.

Academy members who have papers ready for publication should send them in immediately. We probably can use several more in the March issue; if not then certainly in the June issue. Those of you who are planning on presenting papers at the annual meeting in April will receive prompter publication, the earlier the papers are in the editor's hands. Cooperation on your part will greatly aid in prompt publication.

Common Insects of Kansas is the title of a valuable and interesting 440 page book prepared by Roger C. Smith, E. G. Kelley, George A. Dean, H. R. Bryson and R. L. Parker, all members of the Academy and all members of the staff of Kansas State College, Manhattan. The book, which contains 464 figures and six color plates, was published as Report of the Kansas State Board of Agriculture, June, 1943, but was delayed in production until October, 1944. Copies may be secured without charge from Mr. J. C. Mohler, Secretary of the State Board of Agriculture, Topeka.

Remember again that the success of this column depends on Academy members. Please send to the editor or to any other member of the editorial board, news items concerning changes of position, special research projects, appointments, publication of books, awards, etc. The items can be sent at any time for if they are too late for one issue they can be used in the succeeding one.

During September and late fall, the great fields of fruiting grasses are beautiful to behold. On low ground scores of the forked inflorescences of big bluestem may occur on every square yard. The golden panicles of Indian grass glisten in the sun. The dried heads of nodding wild rye stand thickly in the ravines, while on uplands the open panicles of prairie dropseed are held aloft above the level of the foliage. About the first week in September many prairie grasses begin to lose their green color and slowly take on the red and bronze and golden tints of autumn. These gradually deepen until the landscape presents a color scheme rivaled in beauty and delicacy of painting only by the autumnal coloration of the great deciduous forests. Late October or November witnesses the waning and finally the death of the aerial parts of the forbs and grasses. Life in the prairie retreats underground.—Professor J. E. Weaver in *The American Scholar,* V. 13, No. 3, 1944.

The first in time and the first in importance of the influences upon the mind is that of nature. Every day, the sun; and, after sunset, Night and her stars. Ever the winds blow; ever the grass grows. Every day, men and women, conversing—beholding and beholden. The scholar is he of all men whom this spectacle most engages. He must settle its value in his mind. What is nature to him? There is never a beginning, there is never an end, to the inexplicable continuity of this web of God, but always circular power returning into itself. Therein it resembles his own spirit, whose beginning, whose ending, he never can find,—so entire, so boundless. Far too as her splendors shine, system on system shooting like rays, upward, downward, without centre, without circumference,—in the mass and in the particle, Nature hastens to render account of herself to the mind. Classification begins. To the young mind everything is individual, stands by itself. By and by, it finds how to join two things and see in them one nature; then three, then three thousand; and so, tyrannized over by its own unifying instinct, it goes on tying things together, diminishing anomalies, discovering roots running under ground whereby contrary and remote things cohere and flower out from one stem. It presently learns that since the dawn of history there has been a constant accumulation and classifying of facts. But what is classification but the perceiving that these objects are not chaotic, and are not foreign, but have a law which is also a law of the human mind? The astronomer discovers that geometry, a pure abstraction of the human mind, is the measure of planetary motion. The chemist finds proportions and intelligible method throughout matter; and science is nothing but the finding of analogy, identity, in the most remote parts. The ambitious soul sits down before each refractory fact; one after another reduces all strange constitutions, all new powers, to their class and their law, and goes on forever to animate the last fibre of organization, the outskirts of nature, by insight.—
Ralph Waldo Emerson in "The American Scholar," 1837.

Reduced Pituitary Activity From the Influence of Sex Hormones*

E. H. HERRICK and IRENE W. HARTMAN
Kansas Agricultural Experiment Station, Manhattan.

Sex hormones, when administered to experimental mammals, inhibit gonad development in young animals and cause reduction in gonad size in mature ones. These results have been meagerly confirmed in birds, although some observations have been made. (Fig. 1.) It has been assumed that retardation in gonad development, or reduction in size following treatment with sex hormones, is due to reduced activity of the pituitary gland. Since the principal stimulus for gonad development comes from this gland, it is reasonable to believe that altered gonadal development results from altered activity of this controlling gland. A few studies have been made on mammals in which the gonad stimulating properties of the pituitary gland have been determined following treatment with sex hormones but, again, birds have received little attention in this connection.

Since the gonads of fowls become small and inactive upon treatment with sex hormones, it is of interest to learn if the pituitary gland is involved in this sex hormone-gonad response. To test the possible role of the pituitary in this mechanism, a series of three experiments were conducted. These experiments involved the use of male sex hormone (testosterone propionate), female sex hormone (estrone), and a synthetic chemical compound with estrogenic properties, (diethylstilbestrol).

Each group of experimental animals consisted of 10 male single comb White Leghorn chickens that received injections. One group of 10 untreated chickens of the same age and history served as controls for all three groups of treated birds. One group received a total of 44 mg. of male sex hormone each; another group, 5.5 mg. of estrone each; and the third group, 11 mg. of stilbestrol per bird. The material was administered by intramuscular injection, the stilbestrol being first dissolved in corn (Mazola) oil. Each bird received 22 daily injections and was 105 days old when killed.

At the conclusion of the injection period, the treated birds and controls were killed and their testes weighed. In every case the testes of the untreated birds were larger than the treated ones. (See tables.)

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*Contribution No. 239, Department of Zoology.

The pituitary glands were removed in preparation for implantation into young assay chicks.

Female White Leghorn chicks, 7 days old, were used as assay chicks to test the gonadotropic activity of the pituitary glands which were taken from the injected and their control birds. Two pituitary glands were implanted into the breast muscles of each assay chick. The implants were left in place 7 days after which time the assay chicks were killed and their ovaries were removed, weighed and sectioned for histological study. (See tables.) To evaluate the degree of gonadotropic stimulation from the implanted pituitary glands, the ovarian sections were studied. Typical sections were selected and all ovarian follicles were counted. (Five hundred were commonly found in a single section.) These same sections again were examined and all follicles, 50 micra or over, were counted. The percentage of follicles that were 50 micra or over was used as the index of pituitary stimulation.

Results and Summary

Birds that received male sex hormone had testes distinctly smaller than normal birds. The left testes of injected birds averaged 0.356 gm. in weight while the left testes of the controls averaged 7.1 gm. The assay chicks that received pituitaries from the injected birds developed ovaries that averaged 24 mg. in weight, and 13.28 per cent of the ovarian follicles were 50 micra or over in diameter. The assay chicks that received pituitaries from the uninjected birds developed ovaries averaging 39.3 mg. in weight, and 23.85 per cent of the follicles were 50 micra or over in diameter. (Table 1.)

Birds that received estrone did not show so marked reduction in size of the testes as did those receiving the male sex hormone. The left testes of injected birds averaged 4.06 gm. in weight compared to 7.1 gm. for the control group. The assay chicks that received pituitary implants from the estrone-injected birds developed ovaries averaging 31.4 mg. in weight, and 19.9 per cent of the ovarian follicles were 50 micra or over in diameter. These data compare with an ovarian weight of 39.3 mg., and 23.85 per cent of larger follicles in the control chicks. (Table 2.) The fowls injected with 11 mg. of stilbestrol had testes (left) averaging 2.17 gm. for the controls. The ovaries of the assay chicks in this group averaged 28.37 mg. in weight, and 16.4 per cent of the follicles were 50 micra or over in diameter. The companion group of control-assay chicks had ovaries averaging 39.3 mg. in weight, and with 23.85 per cent of the follicles 50 micra or over in diameter. (Table 3.)

Injecting 44 mg. of testosterone propionate, 5.5 mg. of estrone or 11 mg. of stilbestrol, into fowls (105 days old at end of injection period) resulted in a decrease in gonadotropic activity of the pituitary as expressed in gonad reduction in the injected fowls, and reduced activity in stimulating the gonads of young female assay chicks.

TABLE 1.—Testosterone propionate, 22 daily injections, 2 mg. dosage.

	Testis wt. of injected birds and controls. gm.	Ovary wt. of assay chicks. mg.	Per cent of follicles over 50 micra.
Male hormones injected and pituitaries implanted.	0.356	24.00	13.28
Controls—not injected, pituitaries implanted.	7.100	39.30	23 85

TABLE 2.—Estrone, 22 daily injections, 0.25 mg. dosage.

	Testis wt. of injected birds and controls. gm.	Ovary wt of assay chicks. mg	Per cent of follicles over 50 micra.
Estrone injected and pituitaries implanted.	4 06	31 40	19.90
Controls—not injected, pituitaries implanted.	7.10	39.30	23.85

TABLE 3.—Stilbestrol, 22 daily injections, 0.5 mg. dosage.

	Testis wt. of injected birds and controls. gm.	Ovary wt of assay chicks. mg.	Per cent of follicles over 50 micra.
Stilbestrol injected and pituitaries implanted	2 17	28.37	16.40
Controls—not injected. pituitaries implanted.	7.10	39.30	23.85

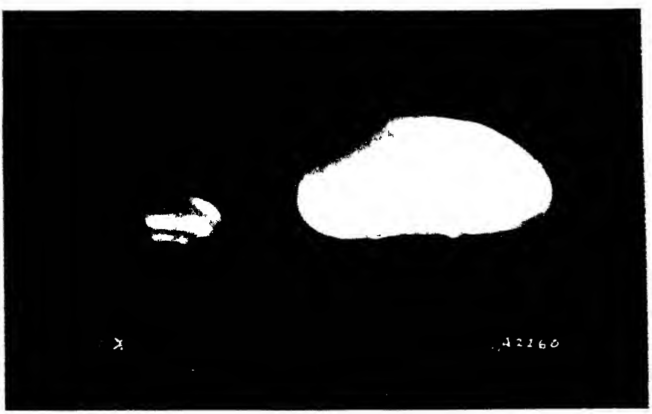

FIGURE 1.—Testes from fowls of the same age. (Left) Testis from bird that had received injections of male sex hormone. (Right) Testis from normal, untreated bird. (Natural size.)

The Importance of Honey Production During War Time*

R. L. PARKER

Kansas Agricultural Experiment Station, Manhattan.

The primary economic function of the honeybee is not that of producing surplus honey and beeswax for the use of man, but that of pollination of certain flowering plants. The honeybee, in seeking its food—nectar and pollen—carries on the process of cross-pollination, which brings about greater productiveness of many farm crops. Pollination is of great importance in seed-setting in fruit and vegetable plants, and in trees and legumes: for in many of these organisms the assistance of an outside agent is necessary to carry pollen from one flower to another. Insects, especially the honeybee, are the most important agents in giving assistance in such cross-pollination.

Another factor which influences pollination is weather. Plants may bloom during cold, inclement weather and may not be promptly pollinated, because such weather conditions are not favorable for insect activity. The honeybee is a creature decidedly influenced by temperature and sunshine; bright, clear weather at the time of blooming of plants during the early spring, favors good pollination.

Effective pollination of plants for food production is extremely important during this World War II. It has been said that "Without honeybees it is doubtful whether the people of America would have sufficient food to eat." Added to our national problem is the far larger problem of producing food for the greater part of the world.

In addition to providing food, it is necessary that we have seeds in order that future food may be produced. Many kinds of fruit, vegetable, tree and legume seeds are in demand for further distribution over the world for rehabilitation of conquered and released nations. Seed is needed for the production of plants for the prevention of various kinds of erosion for, on many waste lands, legumes could be grown which would prevent the washing or blowing of soil. Thus the use of legumes and other beneficial plants prevents erosion and also adds plant food to the soil.

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*Contribution No. 534 from the Department of Entomology.

When colonies of honeybees have been placed in the vicinity of apple orchards, there have been as high as 14 per cent increases in fruit production in some cases. Here is an instance which is cited in Michigan. A 22-year-old orchard had been producing on the average 1600 bushels of fruit before bees had been placed in the vicinity of the orchard. After colonies of bees were placed nearby, the production increased to 4,000 bushels; an example of the assistance honeybees contribute to increased food production. As a general rule, alfalfa seed production varies between 1 and 1.5 bushels per acre where, ordinarily, if the most effective cross-pollination agents, the leafcutter bees, were available, the seed production might range between 6 and 10 bushels per acre. In Kansas, where a few colonies of honeybees have been placed near alfalfa fields, the production has been increased from an average of 1.4 bushels per acre to 2.7 bushels per acre. During these war times, the increased production of alfalfa seed is extremely important. Other examples could be cited showing increased seed production in white clover, red clover, and sweet clovers.

Increase in honey production is also important during this war, because an increased production results in the maintenance of strong working colonies. Strong colonies gather and store more honey, and thus produce more beeswax which is so important in war times for manufacturing purposes. At the same time, such strong colonies effect better pollination over a larger area because of the greater number of worker bees present in such colonies. Also, under sugar restrictions, there is an increased demand for honey as a food by people who are familiar with the use of this natural, unrefined, sweet product. Greater honey production is needed to supply this increased demand.

In honey production, the commercial beekeeper strives for strong colonies at the beginning of a honeyflow. In order to have such colonies at the right time, the beekeeper is alert to brood diseases which must be controlled to prevent losses of colonies. Winter losses and swarming losses can be reduced by the beekeeper by proper management of colonies throughout the year.

With strong colonies at the beginning of spring, the possibility for increased honey production can be brought about by certain manipulations. During April, in Kansas, two-queen colonies may be set up in anticipation of the honey crop production from the major honeyflow which occurs in June. Another method toward the

greater production of honey is to divide strong colonies equally during April. To establish two-queen colonies and divided colonies, extra queens are obtained from queen producers in the South. Under either of the above management plans, the honey crop production will nearly be doubled or more than doubled.

Under favorable conditions, the average surplus of honey production of a well-managed colony in eastern Kansas is 100 pounds. Several strong colonies on scales in the Kansas Agricultural Experiment Station apiary during 1943, which were not divided or set up as two-queen colonies, had a net gain of over 200 pounds per colony for the season. In this apiary of 24 colonies, in which some colonies did not have an opportunity to produce much honey, the average colony production was 166 pounds.

Another necessity in the production of honey is to have a sufficient amount of super equipment to enable the beekeeper to take advantage of a bumper honey crop. During poor crop years, some of this equipment may be unused, due to poor colony management or the seasonal weather conditions. It has been stated that much of the possible honey crop in the United States is lost in any good crop year, due to the lack of super equipment in which the bees may properly store the incoming nectar and the resultant honey.

Extracted honey production is one of the main sources of beeswax production. For every 100 pounds of extracted honey produced, there is a yield of from 1 to 2 pounds of beeswax which is obtained from the cappings of the combs. Another source of beeswax is the wax scrapings from brace and burr comb. Old and poor brood comb can also be rendered for wax. At the present time the demand for beeswax in the United States is double that of the domestic production. During the years 1942 through 1944, there has been and will be an annual demand for approximately nine million pounds of beeswax. The shortage of beeswax in the United States is due primarily to the lack of available ships. Before the war, much of our industrial beeswax came from Africa. At the present time, large quantities of beeswax are on the docks there awaiting shipment. Since the beginning of this war, beeswax has been used in adhesive tape, waterproofing of sails, shells, shell-canvas, machinery going into the tropics, leather boots, and ropes, in addition to the 150 other regular uses of the unique product of the honeybee.

A Comparative Study of Natural and Artificial Revegetation of Land Retired From Cultivation at Hays, Kansas

ANDREW RIEGEL
Fort Hays Kansas State College, Hays.

INTRODUCTION

The growing of crops on cultivated land in the central and western Great Plains region is a comparatively recent practice. Few fields have been tilled for more than fifty years and the major part of the farm land in this region has been under cultivation for twenty-five years or less. Yet in the brief period of time since the virgin prairie gave way to plowed land, hundreds of fields have been abandoned to be revegetated by nature. The reasons for their abandonment are many and varied. Chief among them are drought, duststorms, financial depressions, inability of farmers to adapt farming practices to meet the vicissitudes of climate, and the unwise plowing of areas unfit for cultivation.

The reestablishment of the more important native grasses on these abandoned fields under natural conditions is rather slow and the return of cultivated areas to the original disclimax vegetation requires a considerable period of time. This statement is given credence by several studies which have been conducted in the Great Plains.

Shantz (1) conducted surveys in the western Great Plains which indicated that twenty to fifty years were required to restore buffalo grass to its original state where the cover had been destroyed by plowing and cultivating. Blue grama grass required a greater period of time than did buffalo grass.

In the foot hills of Colorado, Hanson (2) found that many fields had been plowed and later abandoned by homesteaders. After many years these areas supported only weedy plants such as mountain sage, snake weed, three-awned grass, and Texas crab grass. This vegetation had little value as pasture for livestock.

In 1936, Savage and Runyon (3) in extensive studies of abandoned farm land in the central and southern Great Plains found the time required for the more desirable grasses to cover the disturbed soil varied from twenty-five to forty years. This variation was due to a variety of environmental conditions and none of the fields ex-

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amined had attained a cover comparable in composition to that of the virgin prairie.

Booth (4), investigating the natural revegetation of abandoned fields in Kansas and Oklahoma, reported that the oldest field studied had been abandoned for thirty years. This field was in the bunch grass stage of succession and did not appear to be nearing the true prairie stage, indicating more time was to be required to restore climax vegetation on the disturbed soil. Judd and Jackson (5), studying natural succession on abandoned land in western Nebraska, reported that twenty-five to thirty years were necessary to restore climax vegetation in that area.

This paper is a report on data collected and observations made of natural and artificial revegetation of farm land retired from cultivation on the college farm, Fort Hays Kansas State College, Hays, Kansas.

HISTORY OF AREAS STUDIED

Natural Revegetation

In 1920, eighty acres of farm land were fenced in with the college pasture and abandoned. The field was joined on the north, west, and south by native grassland of the mixed prairie type. The upland and gentle south-facing slopes of this grassland were usually occupied by the short grasses, while the steeper slopes and rocky

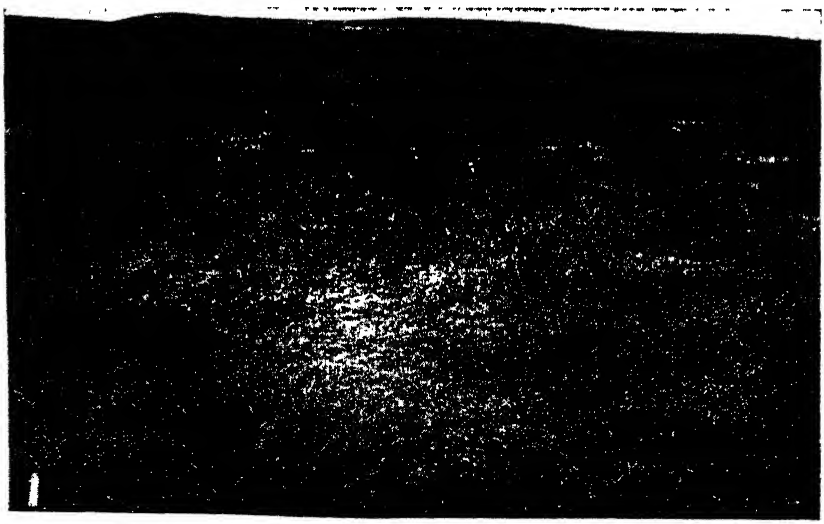

Fig. 1.—General view of field undergoing natural revegetation since 1920. Photograph taken in the spring of 1944. Light spots are buffalo grass.

outcrops were dominated by little bluestem, big bluestem, side oats grama, and other component grasses and forbs.

The field sloped to the south with an incline of three to five percent. The west half of the field was in row crop the season previous to its retirement with the rows running east and west across the slope. There is only slight evidence of the listed furrows at the present time. The east half of the field was in wheat previous to its abandonment.

This field has remained in the pasture since 1920, and has been accessible to grazing livestock during that period. In 1932, an exclosure was established in the field and permanent areas staked out within it for detailed observation. This area has been ungrazed since that time and yearly records have been kept of the composition and the percent of cover of the vegetation in meter quadrats.

Artificial Revegetation

Cultivation was discontinued in 1933 on a second field. The north side of the field borders the large pasture. The south part of the field is fairly level but the north portion slopes toward the north in the direction of the pasture and considerable erosion has taken place in the steeper parts of that area. It was not included in the pasture and remained fallow until 1939, when the north half was cultivated and sown to sudan grass to be used as a cover crop for grass and the south half was farmed as summer fallow in preparation for artificial revegetation.

An area of about two or three acres was left at the east and west ends which was not placed in cultivation a second time, but left to reestablish a natural cover.

REESTABLISHMENT OF COVER

Natural Revegetation

Under natural conditions the revegetation of land retired from cultivation is accomplished by a series of plant successions or subseres. The men previously mentioned, Shantz (1), Savage and Runyon (2), Judd and Jackson (5), and Booth (4), are all agreed on the general pattern which these successions follow in the central and western Great Plains. The first few years after the field is abandoned, the plant cover is composed of annual weeds and annual grasses. These are followed by the less palatable, short lived perennial grasses and biennial and perennial forbs. In the third stage a few of the long lived perennial grasses begin to make their appearance among the less stable perennial grasses and perennial forbs.

The final stage is reached when dominant and subdominant grasses, indigenous to the surrounding undisturbed native prairie, predominate in the area.

The plants involved in the early successions on the field being studied for natural revegetation are not known as no records of the vegetation on the area were kept for twelve years after abandonment. It is presumed that they were similar to those mentioned above. A field one-half mile from the area under observation, after four years of abandonment was occupied largely by lamb's quarters (*Chenopodium album*), Russian thistle (*Salsola pestifer*), and horse tail (*Erigeron canadense*). A few short lived perennial grasses such as wild crab grass (*Schedonnardus paniculatus*) and windmill grass (*Chloris verticillata*) were beginning to make their appearance. Around the edges of the field, sand dropseed (*Sporobolus cryptandrus*) was beginning to invade the area.

Another abandoned field nearby has been out of cultivation for ten years. The vegetation on this area is largely short lived grasses having a basal cover of about twenty percent. Sixty percent of this cover is sand dropseed, twenty percent is wild crab grass, and the remainder is mostly windmill grass. An occasional clump of side oats grama (*Bouteloua curtipendula*) and a few societies of western wheat (*Agropyron smithii*) occur in low places. Near the pasture fence are scattered plants of blue grama (*Bouteloua gracilis*) and buffalo grass (*Buchloe dactyloides*). Very few weeds or forbs are in evidence. Neither of the above areas has been grazed as has been the field within the pasture.

Observers of this grazed field, a few years after its retirement from cultivation recall that weeds, such as Russian thistle and lamb's quarter, covered the area and cattle fed on these early in the spring before the grass began to grow in the native prairie. Later, clumps of buffalo grass were noted in the edge of the field along the north side and the west side where the field joined the native prairie.

In 1932 the first data were recorded on the vegetation of this area, being obtained from permanent meter quadrats staked out in an exclosure. There was a total basal cover of 13.1 percent for the perennial grasses at that time (Table 1). Several grasses were included in this total. Buffalo grass made up 10.5 percent, blue grama one percent, sand dropseed 1.4 percent, and windmill grass 0.2 percent. By 1935 the buffalo grass had a cover of 31.9 percent, blue grama 1.3 percent, and sand dropseed 4.7 percent. Purple triple-awn grass (*Arstida purpurea*) had appeared in 1934 and now occu-

pied 3.5 percent. Windmill grass still hung on with 0.5 percent, giving a total of 41.9 percent. No records were kept for 1936, which incidentally had a very droughty growing season, the rainfall being nearly six inches below normal for the period, April to September inclusive.

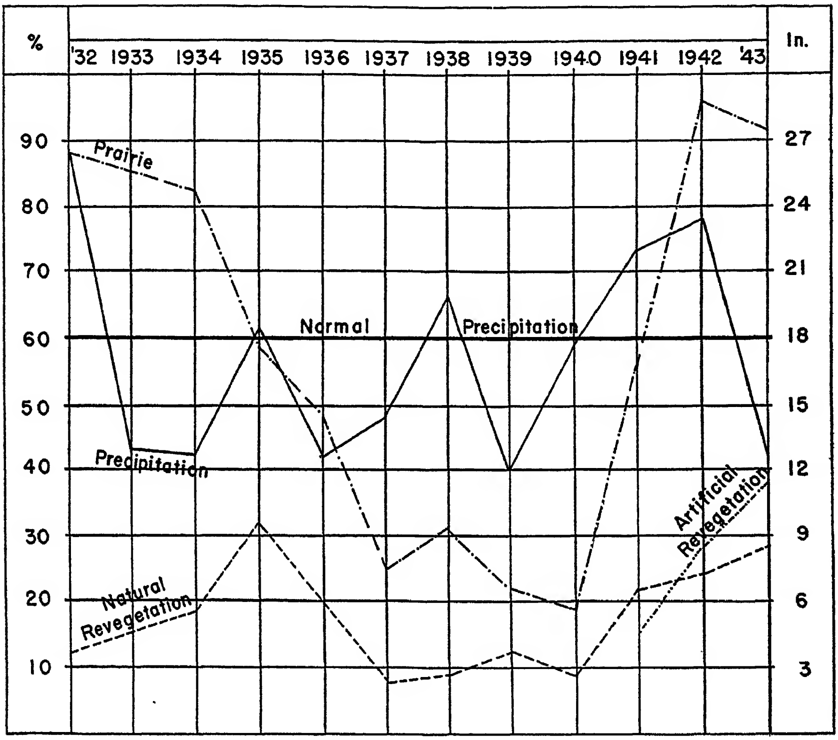

FIG. 2.—Graph showing rainfall for growing season, April to September, inclusive, for 1932-43 with normal for the same period. The basal ground cover is also shown for short grass in the native ungrazed prairie and the natural revegetation area for the same years. The basal ground cover of the short grass in the artificially revegetated area is shown for 1941 to 1943. The left hand column indicates per cent of basal ground cover.

The 1937 growing season was almost as dry and as a result there were serious losses in the vegetation. The basal ground cover of buffalo grass was reduced to six percent, purple triple-awn grass to 0.7 percent, and only a 0.2 percent cover of windmill grass remained. Blue grama held its own with 1.5 percent, while sand dropseed increased to 9.2 percent. The total cover was reduced from 41.4 percent to 17.6 percent.

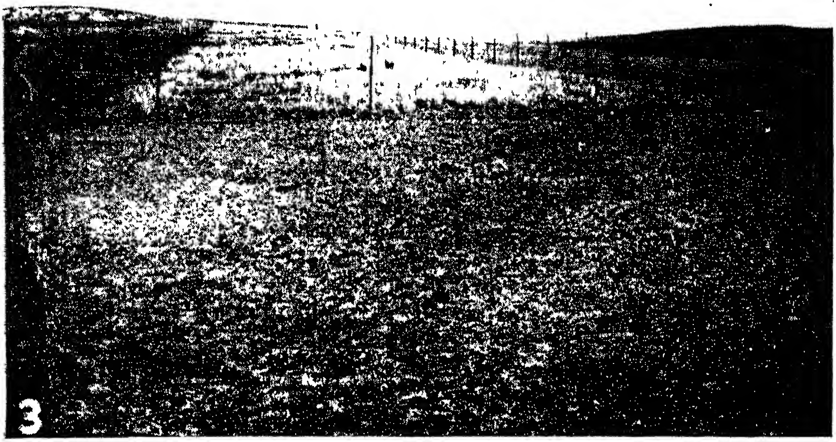

FIG 3.—View showing exclosure in natural revegetation area. Note the open stand of vegetation during summer of 1937. The grass has been closely grazed around the exclosure while sand dropseed is the light colored grass within it

TABLE 1.—The data included in this table represent the average of nine meter square quadrats permanently staked in an ungrazed area of a field which was retired from cultivation in 1920. It is being revegetated naturally. The percentage of basal cover for each species is from 1932 to 1943 inclusive, with the exception of 1933 and 1936 when no records were kept. Bda-buffalo grass, Bgr-blue grama, Scr-sand dropseed, Apu-purple triple-awn grass, Cve-windmill grass.

Year	Bda	Bgr	Scr	Apu	Cve	Total
1932	10.5	1.0	1.4		0.2	13.1
1934	17.9	1.7	2.5	1.0	1.2	24.3
1935	31.9	1.3	4.7	3.5	0.5	41.9
1937	6.0	1.5	9.2	0.7	0.2	17.6
1938	7.1	1.3	10.7	0.6		19.7
1939	11.5	1.9	11 0	0.1		24.5
1940	6.0	2.1	8.2	0.1		16.4
1941	18.1	2 7	11.4			32.2
1942	20 6	3.8	14.0	0 2		38 6
1943	26.6	2 4	7.2	0.1		36.3

The heavy loss of buffalo grass during 1936 and 1937 was possibly due to the severe killing back of partially established stolons. This natural pruning action was necessary to save the deeper rooted parent plants from total destruction. Blue grama and sand dropseed being more sparsely scattered over the area were better able to cope with the moisture deficit because more of the limited supply of water was available to each plant in the very open cover.

During the growing seasons of 1938 and 1939 buffalo grass made a partial recovery, attaining a cover of 11.5 percent by the fall of 1939. Blue grama had increased to about two percent and sand drop-

seed was nearly equal to buffalo grass with eleven percent. Only a trace of purple triple-awn remained and the windmill grass had died out completely. The total cover was increased to 24.5 percent.

An extended drought during the late summer and fall of 1939 again greatly reduced the vegetation in the central Great Plains which had only partially recovered from the losses sustained during 1936 and 1937. In the fall of 1940 after a growing season with about normal rainfall, the revegetation area under discussion had a total basal cover of only 16.4 percent. Buffalo grass again was reduced to six percent, blue grama held about steady with 2.1 percent, and sand dropseed exceeded the short grasses with 8.2 percent. A trace of purple triple-awn grass still remained alive.

The precipitation at Hays, Kansas, was well above normal for the growing seasons of 1941 and 1942. The vegetation of the locality took advantage of the favorable growth conditions to make a rapid recovery. Data obtained in the fall of 1941 and 1942 revealed that buffalo grass had regained a cover of 18.1 percent and 20.6 percent respectively in the revegetation exclosure. Blue grama had nearly doubled its small area, having 2.7 percent in 1941 and 3.8 percent in 1942. Sand dropseed had expanded its growth to 11.4 percent in 1941 and 14.0 percent in 1942. Purple triple-awn grass represented only a trace for the two years. The total cover was 32.2 percent at the close of the 1941 growing season, and had reached 38.6 percent in 1942, being almost back to the 1935 level of 41.9 percent.

The failure of buffalo grass and blue grama to increase more rapidly in 1942 under such favorable conditions of moisture was possibly due to a heavy infestation of prairie ragweed (*Ambrosia psilostachya*), as many as fifty to eighty plants being found in an area of one square meter. They grew to a height of twelve to fifteen inches and quite effectively shaded the ground, as well as extracting a considerable amount of moisture. They were much less numerous in the clumps of buffalo grass, but they prevented the stolons from making any great growth, especially where the clumps of buffalo grass were not large. The blue grama clumps were small for the most part and grew in height to meet the competition for light rather than expanding in diameter. Sand dropseed, normally growing taller than the short grasses, was less affected by the shading of the ragweeds.

A recurrence of drought was experienced during the 1943 growing season. The rainfall again was about six inches below

normal. This drouth was reflected on the plants in the area of natural revegetation although in no way as severely as in 1939.

There was a very definite decrease in the number and size of prairie ragweeds. Rarely more than twenty or thirty plants were found in one square meter of area. They were small and sparsely covered with leaves due to the lack of moisture.

This condition presented an opportunity for buffalo grass to increase its area even with the shortage of moisture. It had a basal cover of 26.6 percent at the close of the 1943 season. Blue grama was reduced to 2.4 percent and sand dropseed, suffering both from drought and the competition of buffalo grass, was reduced to 7.2 percent. A trace of purple triple-awn grass still existed. The total cover of 36.3 percent was slightly under that of 1942. This maintenance of cover in the face of drought is doubtless due to the vigor of the buffalo grass after two seasons of favorable growth and to moisture reserves carried over from 1942. These were used up rather early in the summer so most of the growth was made during the spring. Whether the stolon growth was able to survive the drought will, of course, be answered in the season of 1944. Casual observations indicate there will be little loss.

A reconnaisance survey made of the grazed portion of this field during the winter of 1943-44 estimated the cover of grasses on this area to be about forty percent. Approximately seventy-five percent of this cover was buffalo grass, twenty-two percent was sand dropseed, and one percent was blue grama (Fig. 1). The remaining two percent was windmill grass and wild crab grass. The buffalo grass formed a pure stand in spots from three feet to thirty feet in diameter. Sand dropseed and the other grasses occupied the open spaces between the clumps of buffalo grass. Prairie ragweed was distributed over the entire area, being thickest where there was the least growth of grasses.

The invasion of blue grama into the area is still confined to the

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Explanation of Plates

Fig. 4.—A typical quadrat within the exclosure in the field being naturally revegetated. Buffalo grass is in the right side of the area, sand dropseed to the left. Photographed in 1939.

Fig. 5.—A photograph of the same quadrat as in Fig. 4 during the 1941 growing season. The large prairie ragweed plants (right) shaded the buffalo grass and reduced its growth.

Fig. 6.—A view of the quadrat pictured in Fig. 4 and 5, taken in 1943. Note the sparse foliage of the ragweeds and the small growth of the sand dropseed due to drouth. The buffalo grass showed an increase in cover during the season.

Figures 4, 5, and 6.

margins of the field. Measurements made to determine the frequency of blue grama plants along the north side of the field were summarized as follows:

Distance into field:	Frequency of blue grama plants:
0-100 feet	10 to 15 feet apart
100-200 feet	25 to 50 feet apart
200 or more feet	50 or more feet apart

Artificial Revegetation

The field, which was described earlier in this paper, was prepared during 1939 for seeding to native grass. In the spring of 1940, seven acres of this field were seeded to blue grama, the seed being planted with a common grain drill at the rate of about six pounds to the acre. Half of this was sown on summer fallow ground and half in sudan stubble.

The following spring an additional sixteen acres were seeded to blue grama in sudan stubble at the rate of twelve pounds to the acre. Studies have been made of the progress of these plantings through observations in the field and data collected from permanent quadrats staked out in the seeded areas.

At the close of the first season's growth for the 1940 planting of blue grama, there was growth enough for an average basal cover of 2.5 percent (Table 2), blue grama composing 2.3 percent with the remainder made up of sand dropseed. A heavy growth of Russian thistles, green bristle grass (*Setaria viridis*), and lamb's quarters (*Chenopodium album*) came up in the seeded area and were mowed off in July.

Table 2.—A table showing species of grass and percentage of basal ground cover in a field seeded to grass in 1940. Data represent averages of eighteen quadrats for 1940-1943 inclusive. Bgr-blue grama grass, Scr-sand dropseed.

Year	Bgr	Scr	Total	Year	Bgr	Scr	Total
1940	2.3	.2	2.5	1942	13.2	.3	13.5
1941	8.3	.3	8.6	1943	15.7	1.5	17.2

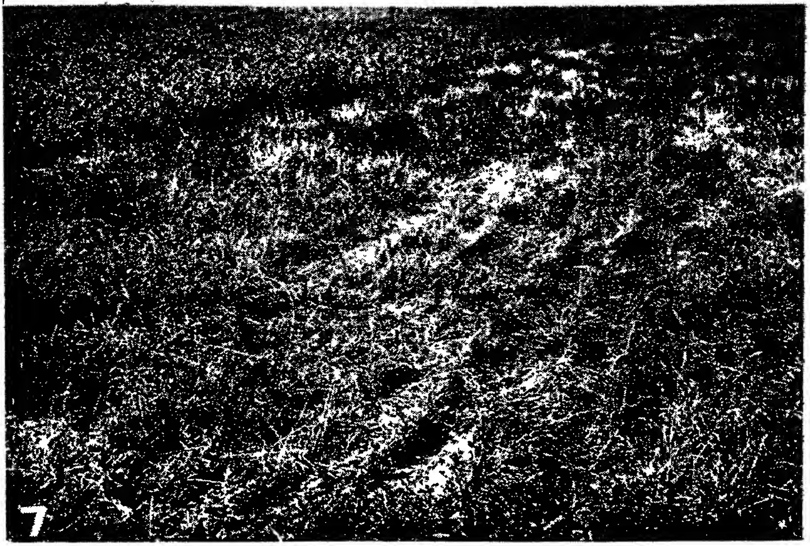
Grasses occupied 8.6 percent of this area in 1941. Of this total, 8.3 percent was blue grama and 0.3 percent was sand dropseed.

The grass was infested with a vigorous growth of annual grasses

Fig. 7.—Blue grama seedlings from which weeds have been removed. A heavy growth of Russian thistle and foxtail can be seen in background to the right. Planting made in 1940.

Fig. 8.—The second season of growth of 1940 planting of blue grama showing heavy infestation of witchgrass and foxtail grass.

Fig. 9.—A view of the 1941 planting of blue grama showing heavy growth of weeds before mowing during summer of 1941.



Figures 7, 8, and 9.

such as green bristle grass and witch grass (*Panicum capillare*), and a scattering of Russian thistles. The weeds were clipped from only one half of the field. This operation was not observed to increase the growth or cover of the grasses over that of the unclipped area. Excellent conditions for growth of vegetation existed during the spring and summer of 1942. The perennial grasses in this field increased to a total ground cover of 13.5 percent. 13.3 percent was blue grama and the remainder sand dropseed.

The predominating weed during the 1942 growing season was horse tail. The plants grew two to three and one-half feet tall and as many as twenty-five to forty in a square meter of area. Due to their tall, compact habit of growth, they did not seriously shade the grass plants.

The area occupied by grasses increased only slightly during the 1943 season of growth. A total cover of 17.2 percent was present in the fall of that year, blue grama comprising 15.7 percent and sand dropseed 1.5 percent of this amount.

The areas seeded in 1941 had much more favorable conditions for germination and growth. Twelve pounds of seed were sown to the acre in a good residue of sudan grass. The grass seed germinated well and grew vigorously, occupying 16.5 percent of the area by the end of the first growing season (Table 3). Except for a trace of side oats grama, the cover consisted of blue grama. Weeds offered much competition and were mowed early in June and again in July to prevent shading of the seedlings.

TABLE 3.—A table of data compiled from seedings of grass made in 1941. The percentage of basal ground cover for each species is from 1941-1943 inclusive and represents an average of seven quadrats. Bgr-blue grama grass, Bcu-side oats grama, Scr-sand dropseed, Asc-little bluestem, Asm-western wheat grass.

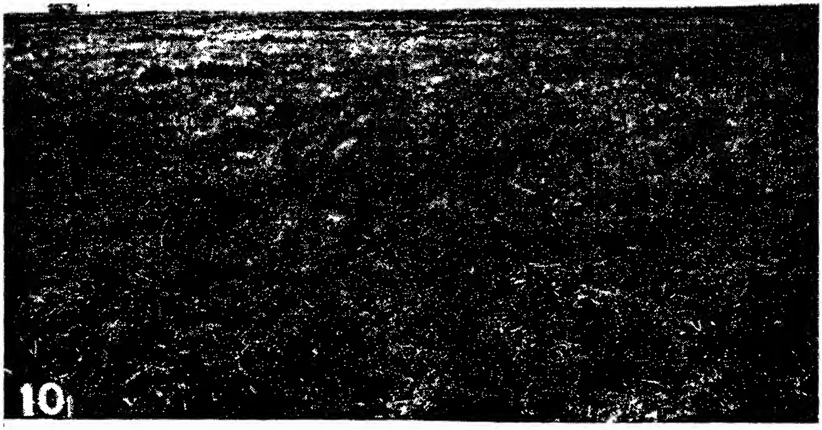
Year	Bgr	Bcu	Scr	Asc	Asm	Total
1941	16 3	0.2				16.5
1942	27.9	0.7	0.1	0.1		28.8
1943	37.1	1.0	0 2	0.2	0.1	38.6

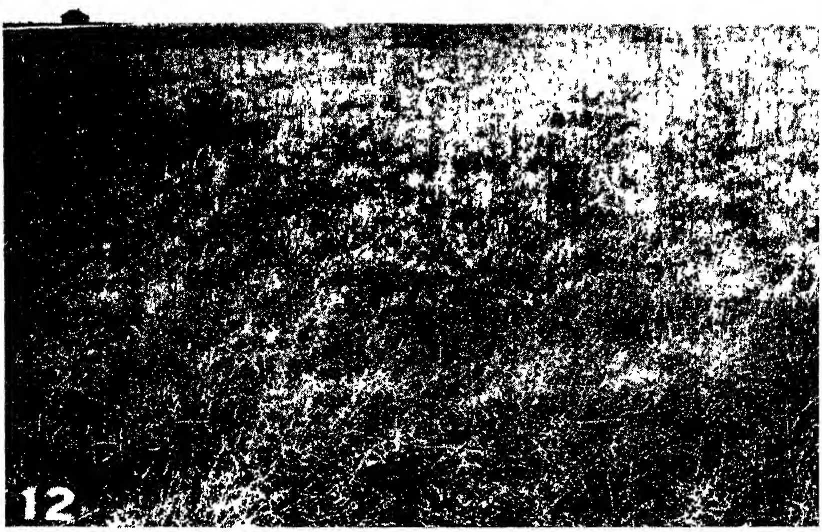
Green bristle grass, switch grass, and stink grass (*Eragrostis cilianensis*) were the principal annual grasses, while Russian thistle (*Solsola pestifer*), annual sunflower (*Helianthus annuus*), wild let-

FIG. 10.—A general view of 1941 planting showing rows of seedlings after weeds had been clipped in summer of 1941.

FIG. 11.—A view taken of 1941 planting of blue grama showing heavy infestation of horsetail weed during growing season of 1942.

FIG. 12.—A view of 1941 blue grama seeding taken in fall of 1943, showing absence of weeds. A few dead stems of horsetail remain from the previous season. Note the heavy cover of blue grama.





Figures 10, 11, and 12.

tuce (*Lactuca ludoviciana*) were the principal weeds. Some thirty-five species of weeds and forbs were noted in the field while making the July mowing. Perennial forbs observed were bracted verbena (*Verbena bracteosa*), wild alfalfa (*Psoralea tenuiflora*), sheep sorrel (*Oxalis stricta*), skeleton weed (*Lygodesmia juncea*), narrow leaved four o'clock (*Allonia linearis*), prairie goldenrod (*Solidago mollis*), false dandelion (*Sitilias grandiflorus*), and wavy leafed thistle (*Circium undulatum*). These plants, for the most part, were seedlings, the seed of which had been mixed with that of the grass.

The grass made a good growth in 1942, and occupied 28.8 percent of the area in the fall of that year. Side oats grama attained a cover of 0.7 percent with traces of sand dropseed and little bluestem (*Andropogon scoparius*). The remainder was blue grama. Weeds were much fewer in this field in 1942. The weedy grasses were scattered over the area and only thirteen species of weeds were recorded, horse tail being by far the most abundant of the species. An average of twelve plants of horse tail were found in a square meter area.

Prairie coneflower (*Ratibida columnaris*), boneset (*Kuhnia glutinosa*), and the many flowered aster (*Aster multiflorus*) were added to the forbs in the field.

The cover of grasses increased to 38.6 percent during the summer of 1943, although the rainfall was well below normal (Fig. 2). Of this cover, blue grama made up 37.1 percent, and side oats grama one percent. Small amounts of sand dropseed and little bluestem were present. A trace of western wheat grass was also recorded. Only a few stunted weeds were present, consisting primarily of Russian thistle, green bristle grass, and horse tail. The many flowered aster, prairie goldenrod, and smooth goldenrod (*Solidago glaberrima*) were the most prominent forbs.

Discussion

It is somewhat difficult to draw comparisons between natural and artificial revegetation since the time involved, expense, carrying capacity for livestock, financial returns, and effect on soil are factors which are not easily evaluated.

Time Involved in Revegetation

In 1932 the short grass in the college pasture, which had been moderately grazed, had an average cover of about eighty-eight percent (Fig. 2). In 1932, after twelve years of abandonment, the field undergoing natural vegetation had a short grass cover of only about

ten percent. This was increased to thirty-two percent in 1935, while the native prairie short grass was reduced to fifty-eight percent. The grass in the native prairie and in the revegetation area received its greatest reduction in cover during the fall of 1939, the cover being only nineteen percent and eight percent respectively at the end of the growing season for 1940.

The improved growth conditions of 1941 caused the native short-grass cover to be increased to fifty-five percent and that of the natural revegetation to twenty-one percent. A field seeded to blue grama in the spring of 1941 had attained a cover of about sixteen percent by fall of the same year. At the close of the growing season of 1942, the ungrazed short grass of the prairie had occupied about ninety-six percent of the area. The cover of the grass in the natural revegetation was about twenty-five percent for the same year, while the 1941 blue grama planting now had increased to twenty-eight percent. The native short grass decreased its area slightly in 1943, while the grass in the natural revegetation area increased to twenty-nine percent and the artificially seeded blue grama to thirty-eight percent.

Thus in three seasons of growth, blue grama, artificially planted in previously cultivated land, had attained a basal cover (thirty-eight percent) which exceeded the total cover of short grass (twenty-nine percent) and sand dropseed (seven percent) growing naturally on land retired from cultivation twenty-four years before.

Expense

The cost per acre of natural revegetation is confined primarily to the interest on capital invested and to taxes on the land. The immediate expenditure per acre in artificial revegetation is considerable. There is the cost of sowing a cover crop, purchasing the grass seed, and the sowing of the seed. Weeds must be mowed one or two times during the first growing season which further increases the total expense.

An example of expenditures involved may be found in the 1941 seeding of blue grama grass. The cost of the cover crop, which was liquidated by having enough growth of sudan grass to permit the harvesting of a crop of hay, would have been approximately two dollars per acre without the hay crop. Listed below is an itemized account of expenditures per acre in seeding an establishing blue grama grass on abandoned cultivated land on the college farm in 1941.

Preparation of ground and seeding sudan grass cover (1940)	$2.00
Twelve pounds blue grama grass seed @ 17c	2.04
Drilling of blue grama grass seed	.50
Mowing weeds in June and July @ 40c	.80
Total cost per acre	$5 34

The total expense will vary according to cost of seed and the labor involved.

CARRYING CAPACITY

The procedure for establishing the carrying capacity for livestock of a native grass pasture has not been completely standardized. Several methods have been used to determine the amount of forage which a pasture would produce or the number of cattle it would feed, but it is not the author's intention to enter into a discussion of these factors in this paper. It is necessary, however, to compare the natural and the artificial revegetation of undisturbed areas in the light of their food resources for grazing livestock because it is on this basis that financial returns may be determined.

The natural revegetation area after fifteen years had attained a basal ground cover of about 42 percent. Of this vegetation 32 percent was buffalo grass, the other 10 percent being sand dropseed and other less palatable grasses. The artificial revegetation area, three years after planting, had a cover of 38 percent which was practically all blue grama grass. These two fields, at this point in their revegetation, would support about the same number of animal units per unit area since blue grama and buffalo grass are given the same palatability rating, and clipping yields (unpublished data) indicate the two grasses produce about the same amount of forage per one percent basal cover.

Limited data are available for yields per acre of short grass including percent of basal cover. Lacey (6) at Hays, Kansas in 1939, obtained a yield of 455 pounds (air dry weight) of short grass from a cover of 28.9 percent. Albertson (7) in studying forage yields of native grasses at Hays, obtained 538 pounds of short grass per acre from a 20.1 percent cover in 1940, 902 pounds per acre from a 43 percent cover in 1941, and in 1942 an 83.7 percent cover yielded 1650 pounds of forage per acre. The yield per acre for 1943 (unpublished data) was reduced to 674 pounds, but the cover remained about 84 percent.

An average taken for the five years (1939-1943) gives a yield of 844 pounds per acre with a cover of 52 percent. Using these averages the yield per one percent cover would equal 16 pounds per acre. If this figure is arbitrarily used on the basal covers for the

revegetation areas to determine their yields, the natural revegetation area (42 percent) produced about 630 pounds of forage to the acre and the artificial revegetation (38 percent) yielded 570 pounds per acre.

Morrison (8) states that a pregnant beef cow weighing 1000 pounds should receive 14.5 to 20 pounds (air dry weight) of forage per day to keep in good health. Arbitrarily taking 18 pounds as an average daily requirement for a mature animal in this study, a comparison may be made of the carrying capacities of the two methods of revegetation. Using the above average requirement, the area being revegetated naturally would, after fifteen years, have supported one mature animal for twelve months on 10.6 acres, or stated in range research terms, the area had a carrying capacity of about 10.6 acres per animal unit. The artificially revegetated area, after three years, had a carrying capacity of twelve acres per animal unit. Since clipping removes most of the vegetation the above carrying capacities would represent heavy grazing practices.

Observations made by the author and others and data recorded by Booth (4) indicate that the climax grasses under natural conditions return slowly to abandoned farm land. They rarely form any appreciable part of the plant cover in an abandoned field before ten years, and often it is much longer. Twelve years after abandonment, the field under natural revegetation in this study had a total basal cover of 13.1 percent of which 10.5 percent was buffalo grass. It is reasonable to assume that a small percent of the cover was buffalo grass as early as ten years after abandonment. Disregarding weeds and short lived grasses, the area was of little value for grazing during the first ten years of abandonment while the area seeded to grass was supporting a 38 percent cover which was largely blue grama grass the third season after it was planted. This cover can reasonably be expected to increase since it is not uncommon to find blue grama grass with a cover of 70 percent and more in the native prairie. This statement is also true of the buffalo grass cover in the natural revegetation since a cover of this grass reaching 85 to 95 percent is common in the native short grass pasture lands.

Financial Returns

It is apparent from the above discussion that the difference in relative values for grazing of the vegetation produced by the artificial and the natural methods of revegetation comes during the first fifteen or twenty years. After the natural reversion to grass has produced a cover of dominant forage grasses comparable to that in

the seeded area, then the forage yields of the two pastures should not be greatly different. Financial returns from pasture lands are based primarily on the yields of palatable forage produced by them. Livestock, utilizing this forage for food, turn it into live weight, a product which is marketable and hence has financial value. Black (9) found in the northern Great Plains that two year old steers when grazing on native grasses (40 to 50 percent of which was short grass) gained an average of fifteen pounds per acre during the grazing season which lasted an average of 138 days. The short grass of this grazed area yielded about 320 pounds (an average for five years) when clipped monthly. As this yield is about 50 percent of the total yield for all grasses in the grazing area, about eight pounds of gain per acre could be credited to short grasses; roughly a gain of one pound for each forty pounds (air dry weight) of short grass harvested by clipping.

Data collected by Sarvis (10) in the northern Great Plains indicate an average of about sixteen pounds (air dry weight) of short grass produced for each percent of basal cover when the grass was clipped monthly. The data reported by Albertson on the yield of short grasses at Hays, Kansas, and mentioned earlier under the discussion of yields also shows an average yield of about sixteen pounds per one percent basal cover when clipped each month.

Using the above data as a basis for comparison, average returns from the natural and the artificial revegetation may be approximated. The short grass in the area being naturally revegetated, had an average cover of seventeen percent for a twelve year period from 1932 to 1943. Sand dropseed had an average of eight percent for the same period. This cover would constitute an approximate yield of 360 pounds of forage per acre for each year of the period, capable of providing about nine pounds of gain per acre for a two year old steer. From 1920 to 1932 the area produced very little forage of value for grazing, so most of the returns in pounds of beef per acre from the area are represented in the twelve years above and would total about 120 pounds for the 24 year period.

The area seeded to grass in 1941 would have been ready for grazing in 1943. In the fall of that year the grass had a basal cover of 38 percent. This cover would approximate a yield of 600 pounds of forage which could produce about fifteen pounds of gain per acre. Assuming this area had been in existence for 24 years with an average cover of 38 percent, it would have yielded a total potential return of 360 pounds of beef.

Thus, with an expenditure of a little over five dollars for revegetation, an acre of abandoned land at Hays during the first 25 years would produce three times as much beef as a similar area revegetated under natural conditions. The beef produced would liquidate, in less than ten years, the cost of establishing the cover of grass artificially.

SUMMARY

The major portion of the crop land in the central and western Great Plains region has been under cultivation for twenty-five years or less, but in this time many fields have been abandoned for various reasons and allowed to be revegetated by nature.

Surveys conducted by several investigators indicate the return of the more important native grasses to these fields is slow and the establishment of the original disclimax vegetation requires many years.

A cultivated field on the college farm at Hays, Kansas, was retired from cultivation in 1920 and made a part of the native grass pasture. Twelve years after its abandonment, buffalo grass covered about ten percent of the area and three years later the grass had increased to a cover of about thirty-five percent.

Twenty-four years after being retired from cultivation the grasses of the field totaled about 36 percent, of which 26 percent was buffalo grass, and two percent was blue grama. The native short grass prairie at the same time had over 90 percent.

A second field was taken out of cultivation and part of it sown to blue grama in the spring of 1941. The grass occupied about 16 percent of the area sown at the end of the first growing season and had attained a cover of 38 percent by 1943. Heavy infestations of weeds were present in the field during the first two growing seasons, but were few in number and small in size in 1943. In three seasons of growth, blue grama, seeded on retired farm land, had a basal cover of grass exceeding that of the field which had been undergoing natural revegetation for twenty-four years.

The cost per acre of natural revegetation is confined primarily to interest and taxes on the land, while in artificial revegetation the immediate cost per acre is considerable. An expenditure of over five dollars per acre was made in establishing the stand of blue grama in 1941. After three years growth the area seeded to blue grama had about the same carrying capacity for livestock as the area undergoing natural revegetation had fifteen years after retirement from cultivation.

Clipping yields of short grass indicate that blue grama and buffalo grass yield about the same amount of air dry forage per one percent basal cover. An average yield over a five year period was sixteen pounds per one percent cover of short grass at Hays, Kansas.

Little forage of value for grazing was produced on the natural revegetation area during the first ten or twelve years after its being retired from cultivation in 1920. During the twelve years (1932 to 1943) an average cover of twenty-five percent was maintained with an approximate yield of 360 pounds of forage per acre. Calculated yields per acre of the two revegetation areas indicate that during the first twenty-five years after retirement from cultivation, the field seeded to blue grama would have produced three times as much beef as the one undergoing natural revegetation.

The cost of artificial revegetation could be liquidated within ten years after seeding.

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Effect of An All Plant Ration on the Resistance of An Omnivorous Animal to Parasitism[1]

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Early in the present century Looss observed in Egypt that a heavy meat diet was unfavorable for certain parasitic worms. Twenty years later Ackert noted in Trinidad, British West Indies, that a diet lacking meat was favorable for helminths, especially the human ascarid, *Ascaris lumbricoides,* which in some instances formed infestations of 100 or more worms in persons whose principal diet was bread and tea. In another decade, Hegner conducted tests which showed that a carbohydrate diet favored the multiplication of certain human protozoan parasites. However, several elderly people who may have been free from parasites were maintaining that they had better health while on meatless (vegetarian) rations, although they did partake of such animal products as milk, butter, cheese, and fish.

At that time Ackert and his associates had just demonstrated that the natural resistance of chickens to the viability and growth of their ascarid worms *(Ascaridia lineata)* was lowered when the fowl ration lacked vitamin A (Ackert, McIlvaine, and Crawford, 1931). This result led to tests of certain protein supplements as a possible factor in natural resistance of chickens to *Ascaridio lineata* (Ackert and Beach, 1933).

In these tests, chickens from the same hatch were divided into three groups, parasitized with the same number of ascarid eggs, and placed on a cereal basal ration adequate except for the protein supplements. The ration for Group 1 contained as a supplement 11.22 per cent by weight of meat meal and liquid skim milk *ad libitum;* Group 2 was given a diet identical with that of Group 1 except the skim milk, which was omitted. The diet for Group 3 lacked animal supplements. Instead of meat meal, 11.1 per cent by weight of peanut meal was added. All groups were supplied with fresh water.

The results of the tests on 140 chickens showed that those on the meat and milk supplements made the best growth; those on the

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[1]Contribution No. 242 from the Department of Zoology, Agricultural Experiment Station, Kansas State College of Agriculture and Applied Science, Manhattan, Kansas.

meat supplement the next best, and the chickens on the peanut meal supplement, the slowest growth.

The highest resistance of the chickens to the viability (numbers) and growth (length) of the nematodes was found in the group on the meat and milk supplement. The worms in these chickens were much fewer and shorter than were those in the groups having only meat or peanut meal supplements. The chickens having the most and longest worms were in Group 3. These facts indicated that the resistance of the chickens on the peanut meal supplement was low against the growth of the intestinal parasites. A second experiment gave similar results. The results of these tests indicated that a cereal basal ration supplemented with the meat and milk produced higher resistance in chickens to the parasites than a cereal ration supplemented with a like percentage of peanut meal. From examining all of the results it appeared that animals and persons on a ration wholly of plant origin (vegetarian) would not be as resistant to parasitism as they would be on a cereal ration supplemented with meat and milk.

With the scarcity of meat and milk during the war effort, it seemed desirable to ascertain if the resistance of animals to parasitism would be lowered if soybean oil meal were substituted for meat scrap or meat scrap and powdered milk as supplements to a cereal basal ration. Five experiments were carried out on a total of 304 chickens in much the same way as in the peanut meal, meat scrap and milk tests reviewed above. All chickens under comparison were from the same hatch and were of the same comparative weights at the beginning of the experiment. Later each chicken was given the same number of worm eggs, approximately 100. To a cereal basal ration adequate except for protein supplements, there was added slightly over 14 per cent of protein supplement. Group 1 received meat scrap and powdered skim milk, Group 2 meat scrap, and Group 3 received soybean oil meal. Each ration was thorouoghly mixed and fed in hoppers. Fresh water was kept before the chickens at all times. Weekly weights were recorded for each chicken.

After being on the respective rations for seven weeks, the chickns were killed and the worms collected, counted, and measured in length to determine the comparative growths of the worms, and indirectly the resistance of the chickens to the parasites. The criterion for judging the resistance of the chickens was the comparative lengths of the worms in each group at autopsy.

When the worms of the various groups were measured, the evidence showed that Group 3 (on the soybean oil meal supplement)

was as resistant to the growth of the worms as were the chickens in Group 1 (meat and milk) or Group 2 (meat supplement). The average worm length for Group 1 was 20.5 mm.; for Group 2, 20.6 mm.; and for Group 3, soybean oil meal supplement, 19.7 mm. In numbers of worms per group there likewise were but small differences which fell within the range of experimental error.

As to fowl growth, the chickens of the three groups averaged very nearly the same weight. In the first experiment, Group 1 grew slightly the fastest. In the second experiment, Group 3 made slightly the best growth as they also did in Experiment III. In Experiments I and V, Group 1 (meat and milk powder) grew slightly the best and in Experiments II and IV, Group 3 made slightly the best growth, while in Experiment III, all three groups made nearly the same in growth.

Only in the matter of feathering and early development of the males did Group 1 (meat and milk) surpass the other groups. The results of the experiments indicate that soybean oil meal used as a 14 per cent supplement to an otherwise adequate cereal ration is as effective as a meat scrap or meat scrap and powdered skim milk supplement in developing resistance of chickens two months of age to the growth of the nematode *Ascaridia galli.*

The reason why soybean oil meal as a supplement resulted in more resistance in the chickens to the parasites than did the peanut meal probably lies in the fact that it is more readily digested and utilized by chickens than is peanut meal. Van Landingham, Clark and Schneider (1942) found that chickens under 18 weeks of age were able to utilize 76 per cent of the protein in soybean oil meal, whereas Fraps (1928) found that only 34.5 per cent of the protein in peanut meal was digestible in poultry.

From the present tests with chickens, which are omnivorous animals, it may be inferred that for young fowls up to two months of age an all-plant diet which includes soybean oil meal as a supplement may function as well as a meat or a meat and milk supplement in developing resistance of an animal to parasitism.

The milk supplement developed more smoothness of coat and more rapid approach toward sexual development as manifested by earlier crowing of young cockerels, but it did not significantly increase the growth in weight nor the resistance of the animals to their parasites.

Summary

1. The results of a series of tests on protein supplements to an otherwise adequate cereal ration for growing chickens showed that soybean oil meal as as effective a supplement as meat scrap or as meat scrap and powdered skim milk in producing resistance in chickens two months of age to the nematode *Ascaridia galli.*

2. Results of previous experiments in the series had demonstrated that peanut meal as a protein supplement to a cereal basal ration was inferior to a supplement of meat scrap and milk in producing resistance in chickens to the viability and growth of these ascarid worms.

3. The greater effectiveness of soybean oil meal as a supplement is attributed to its higher percentage of digestibility.

4. Under the conditions of these experiments an all-plant ration was as effective as a plant and animal ration in producing resistance to parasites in an omnivorous host.

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Elasticity of Plant Tissues

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I. Introduction

In the seventeenth century Galileo Galilei found the mechanical principle of the mechanism of the human body. He had the first exact views about stress and strain in the tubular bones of animals. In the nineteenth century S. Schwendener, who was both botanist and engineer, investigated the factor of strength in cylindrical stems of plants. Schwendener showed that their strength was concentrated in the bundles of bast tissue (1, 2). He found that at the limit of elasticity the bast fibers of the plants he investigated had a stress of about 20 kgs. per sq. mm. The steel wire which was in use at that time had a stress of 25 kgs. per sq. mm. Schwendener did not investigate stress-strain curves. In 1942 stress-strain curves of the horizontal rhizomes of Equisetum were investigated by the author of this paper (3).

There now remains the question as to whether some of the properties found in rhizomes of Equisetum are true in general cases. It will be shown that there are some general laws for elastic plant tissues and also for elastic animal tissues. The new experiments were carried out during July and August, 1943 at the University of Michigan Biological Station.*

II. Method

The plant tissue to be studied is held horizontally between two clamps, one movable and the other fixed. The movable clamp and the aluminum pan with weights are connected by a piano wire, gliding on a pulley.

The stress-strain curve of the plant tissue tested is obtained by measuring the strain and corresponding stress. The weight of F gms. or $F \cdot 980$ dynes acts as tension or stress $y = F \cdot 980/A'$ dynes/cm^2 where A' cm^2 is the area of the cross section of the plant tissue. The corresponding strain of the plant tissue of 1 cms. length is strain $x = e/l$, where e cms. is the elongation produced by weight F gms.

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*I wish to express my appreciation to Dr. A. H Stockard, Director of the Station, for the use of laboratory facilities.

If we plot a curve with x as abcissa and y as corresponding ordinate we get the stress-strain curve. This curve generally is twice bent or S-shaped.† The first part of the curve corresponds to the elastic condition. The larger second part of the curve gives the stress-strain relations in the range where the plant material is no longer elastic. The end of the curve is the breaking point for the material tested.

For our living material the elasticity of an object is greater, the smaller the modulus of elasticity (3).

III. Elasticity of Plant Tissue with Respect to Different Structure

a. Petioles of *Nymphaea tuberosa*

The stress-strain curves of petioles of *Nymphaea* are ascending curves, not S-shaped curves (Fig. 3). An average curve is characterized by the points of curves II, III, IV, VI, and VII. The boundary of elasticity is given in the curve near the beginning of the flat part. At the boundary of elasticity the average stress is 12.2 kg/cm^2, and the strain 0.024 (Fig. 3). The modulus of elasticity is 5.0×10^8 dynes/cm^2. The modulus of elasticity of rhizomes of *Equisetum fluviatile* of wet habitat was 4.1×10^8 dynes/cm^2 (2). That means the moduli of elasticity are not very different. Petioles of *Nymphaea tuberosa* and rhizomes of *Equisetum fluviatile* have the greatest elasticity we observed in plants. A value of stress equal to 12.2 kg/cm^2 at the boundary of elasticity is the smallest value observed in plants. According to A. Arber (4) waterlilies, where they are abundant, cover every available square inch of water. The blades of the leaves secure a place in the sun through the pliability of the petioles, therefore the good elasticity (very small modulus of elasticity) of the petioles of *Nymphaea* is of great ecological importance.

The cross section of petioles of *Nymphaea odorata* has many air chambers (Fig. 1), and the vascular bundles are not very significant.

Explanation of Figures—Plate I

Fig. 1. Cross section of a petiole of *Nymphaea odorata* with many air chambers (a).

Fig. 2. Cross section of a stem of *Brasenia schreberi* with numerous air chambers (a) and four vascular bundles (v).

Fig. 3. Stress-strain curves of petioles of *Nymphaea tuberosa*.

Fig. 4. Stress-strain curve of stem of *Brasenia schreberi*.

Fig 5. Stress-strain curve of root of *Rhus glabra*.

Fig. 6. Stress-strain curves of sclerenchymatous plates of rhizomes of *Pteris aquilina*.

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†If the x and y axes are interchanged we recognize the S shape.

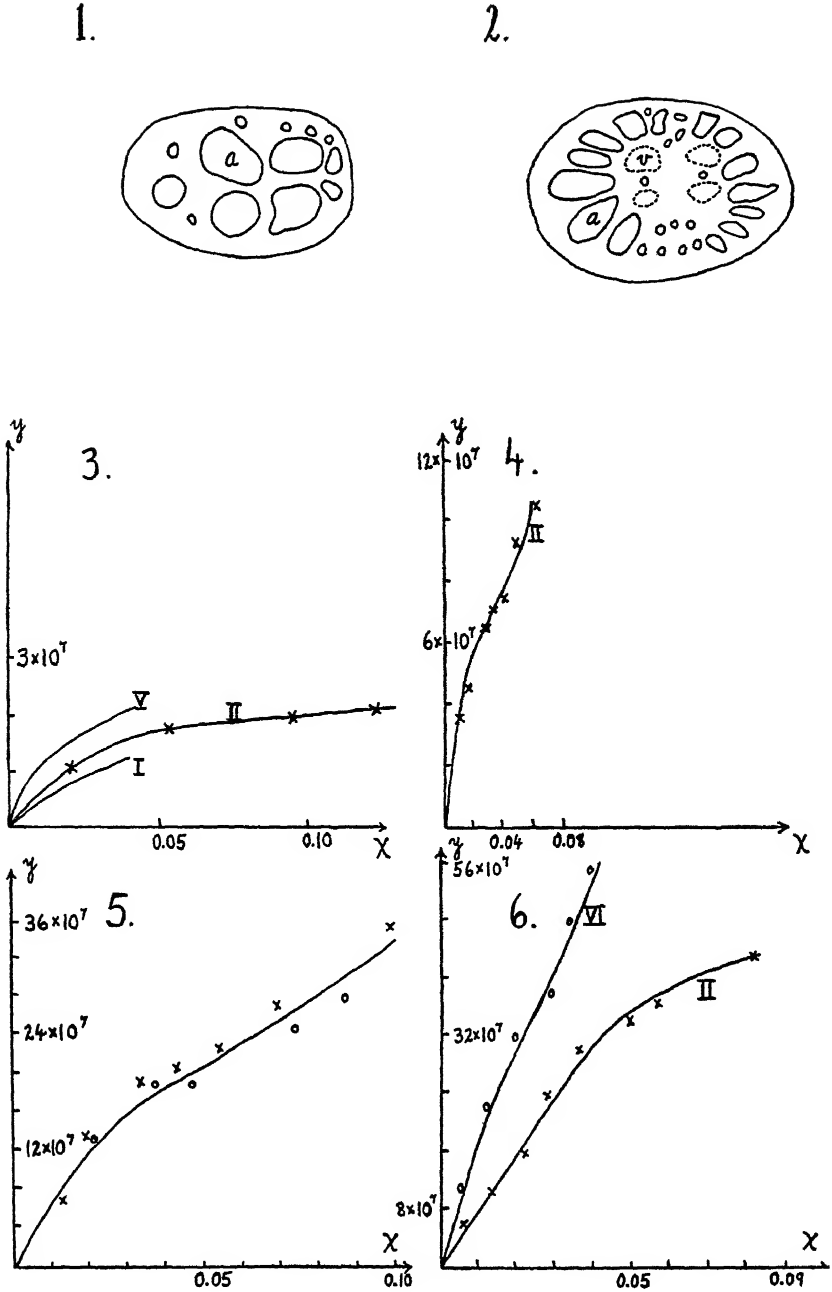
1.
2.
a
v
a
3.
y
3×10⁷
V
II
I
0.05
0.10
x
4.
y
12×10⁷
6×10⁷
II
0.04
0.08
x
5.
y
36×10⁷
24×10⁷
12×10⁷
0.05
0.10
x
6.
y
56×10⁷
32×10⁷
8×10⁷
VI
II
0.05
0.09
x

Plate I.

Cross sections of *Equisetum fluviatile* rhizomes have the same characteristics; but the cells of the epidermis have thick walls in rhizomes of *Equisetum fluviatile* and thin walls in petioles of *Nymphaea.* Because of this difference in structure the boundary of elasticity with respect to stress and strain is three times greater in rhizomes of *Equisetum fluviatile* than in the lighter built petioles of *Nymphaea;* in addition, there is a difference in the shape of stress-strain curves. The stress-strain curves of petioles of *Nymphaea* are ascending curves. Such ascending stress-strain curves are found for plastic deformation of solid bodies (5). The petioles of *Nymphaea* do not undergo permanent changes of form like plastic bodies, but two other characteristics typical of plastic bodies are found. Petioles of *Nymphaea* change the shape at very small stresses ,and the range of elasticity is small, so there may be a connection between both kinds of curves. (See Part V b). The breaking stress of petioles of *Nymphaea tuberosa* has the very small value of 20.4 kg/cm^2 and the breaking strain is 0.12 according to the average curve II of Fig. 3.

b. Stems of *Brasenia Schreberi*

The stems of *Brasenia schreberi* were collected at the edge of Black Lake. The stress-strain curves of such stems are S-shaped (Fig. 4). An average curve is given by curve II of Fig. 4. Generally the stems broke at the nodes. Hence the nodes are the weakest parts of the stems of *Brasenia.* At the boundary of elasticity the average stress is 53.1 kg/cm^2 and the average strain is 0.02. By using curve II the modulus of elasticity is 28.5×10^8 $dynes/cm^2$. The range of elasticity for *Brasenia* is thus much larger than for petioles of *Nymphaea.* The stress-strain curves are steeper for *Brasenia* than for *Nymphaea.* The breaking stress is 81.6 kg/cm^2 and the breaking strain is 0.05. The cross section of stems shows many air chambers which means great elasticity (Fig. 2). The epidermis has thick walls and there are four large vascular bundles; the stems are therefore of heavier build than the petioles of *Nymphaea.* The stems of *Brasenia* are less elastic than the petioles of *Nymphaea.* The steepness of the stress-strain curves of *Brasenia* also proves the decreased elasticity.

c. Roots of *Rhus glabra*

The determination of the size of the cross section A′ of the plant material investigated was first made, vernier calipers being used to measure the diameter. Since several experiments yielded the same stress-strain curves with or without the thin bark, considera-
54×10^8 $dynes/cm^2$ from the curve. The stress-strain curve is very

tion of the bark was left out in making computations. By superimposing a drawing of the xylem upon cross-ruled paper it was determined that the solid part constituted 0.3 of the cross section of the root.

The experimental points of the stress-strain curves are near an S-shaped average curve (Fig. 5). At the boundary of elasticity for the wood of roots of *Rhus* the stress was 131.6 kg/cm^2 and the strain was 0.025. The value of the modulus of elasticity was found to be steep (Fig. 8) and approximately a straight line. It was to be expected that material so heavily built up as wood (the thin bark is neglected) would have but little elasticity. By Hooke's law we get a straight line as stress-strain curve for metals. The agreement observed means that wood has approximately metallic elasticity. The breaking stress has the large value of 282.6 kg/cm^2 (average value of measurements) and the breaking strain is 0.08 (from curve Fig. 5).

For the breaking stress of a quill of a wing feather of the blue jay we found a similar value of 301.6 kg/cm^2.

d. Sclerenchymatous plates of Rhizomes of *Pteris aquilina.*

Schwendener (1, p. 14) found values of about 2000×10^8 dynes/cm^2 for the modulus of elasticity of the bast fibers he investigated, which means the stress-strain curves for such fibers have to be very steep with straight lines in the range of elasticity. To obtain proof of such straight lines we investigated the elasticity of the sclerenchymatous plates of rhizomes of *Pteris*. In pictures of the cross section of rhizomes these dark plates are obvious (6). The sclerenchymatous plates are easily cut from the rhizomes and were then investigated.

The stress-strain curves are very steep (Fig. 6), and the average modulus of elasticity is 115.9×10^8 dynes/cm^2. From Fig. 8 is seen that the curves are much more straight lines than the curves for roots of *Rhus glabra*. Curve VI in Fig. 6 has only a very small indication of the S-shaped curve. The average breaking stress for the sclerenchymatous plates is 704 kg/cm^2. This value is about one-third of the values which Schwendener found in bast fibers at boundary of elasticity. According to Schwendener the difference between stress at the boundary of elasticity and breaking stress for the fibers he investigated is very small (1, p. 14).

e. Stress-strain Curves of Different Plant Tissues

In Figure 8 all curves are drawn to the same scale.

1. It is seen that soft or lightly built up tissues are very elastic and that hard or heavily built up tissues are less elastic. The modulus of elasticity of soft tissues is very small, but the modulus of elasticity of hard tissues is very great. Values for rubber and different metals are expressed in the following table (7):

	Brinell hardness kg/mm²	Modulus of Elasticity kg/mm²
Vulcanized rubber	7 to 16	about 0.08 (8)
Aluminum	20 to 28	7200
Zinc	45	13000
Copper	60	12500
Steel	150 to 850	21500

This table shows that for certain metals and rubber, low hardness corresponds to low modules of elasticity and great hardness corresponds to great modulus of elasticity. The same behavior was found for the plant tissues we investigated.

2. Figure 8 shows that for different elastic plant tissues there is a slow change from the S-shaped stress-strain curve to the straight line, from rubber-like elasticity to metallic elasticity. The curve for petioles of *Nymphaea* may be considered as an S-curve with the superior part in infinity.

3. Figure 8 gives the average results of the plant tissues investigated. Other material of the same plant tissues may give other average results; but it is probable that the general shape of Figure 8

EXPLANATION OF FIGURES—PLATE II

FIG. 7. Stress-strain curve of a tendon of a chicken leg (t). Stress-strain curve of intestine (i). The scales for both curves are different. On the "y" axis the left hand values apply to the intestine, the right hand values to the tendon. On the "x" axis the lower values apply to the intestine, the upper to the tendon.

FIG. 8. Stress-strain curves of different plant tissues.
P=curves of sclerenchymatous plates of rhizomes of *Pteris aquilina.*
R=curve of woody root of *Rhus glabra.*
B=curve of stem of *Brasenia schreberi.*
N=curve of petiole of *Nymphaea tuberosa.*

FIG. 9. Theoretical stress-strain curve.

FIG. 10. Experimental and theoretical stress-strain curves of the stem of *Brasenia schreberi,* solid line—experimental; dashes—theoretical.

FIG. 11. Experimental and theoretical stress-strain curves of the petiole of *Nymphaea tuberosa,* solid line—experimental; dashes—theoretical.

FIG. 12. Growth curve of *Lupinus albus.*
x=length in mms.
t=time in days.

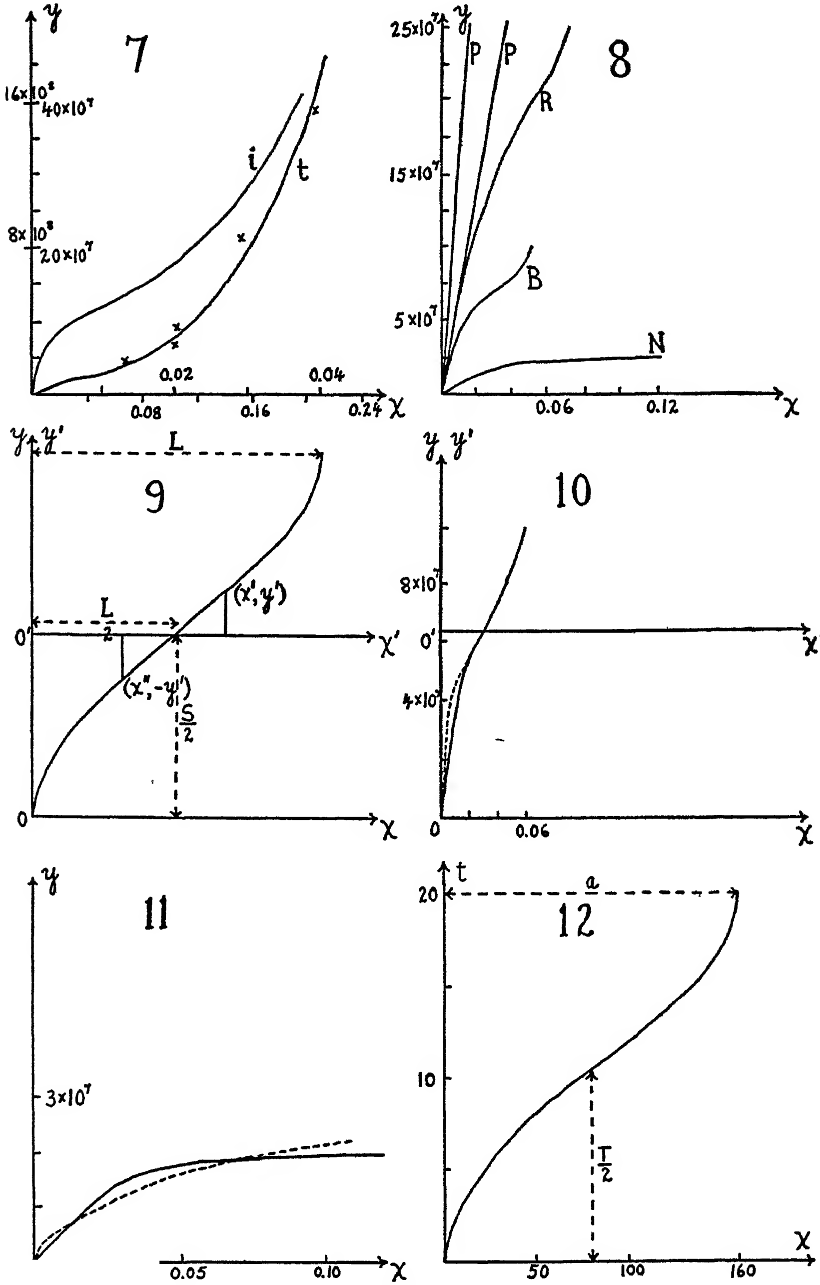
7
y
16x10⁸
40x10⁷
8x10⁸
20x10⁷
i
t
0.02
0.04
0.08
0.16
0.24
x
8
25x10⁷
15x10⁷
5x10⁷
P
P
R
B
N
0.06
0.12
9
L
L/2
(x', y')
(x'', -y')
S/2
O'
0
x'
10
y y'
8x10⁷
4x10⁷
0.06
11
3x10⁷
0.05
0.10
12
t
20
10
a
T/2
50
100
160

Plate II.

will remain the same because of the great differences of our values of moduli of elasticity and of structure of the plant tissues investigated.

IV. Elasticity of Animal Tissues

I wish to express my appreciation to Dr. Charles W. Creaser who aided me in obtaining animal tissue for the following experiments. The problem is to determine whether there are similar stress-strain curves for animal tissues as those which have been found for plant tissues. For the animal tissue experiments we used the same method as already described for plants.

a. Fresh Muscle of Rooster Wing

The wing of the rooster contains muscles of regular spindle shape. The cross section of such muscles is easily measured and hence these muscles were investigated. The stress-strain curve of fresh muscles is an ascending curve (the initial part is questionable). It is interesting that the curve of the material investigated was congruent with the average stress-strain curve of petioles of *Nymphaea tuberosa* (Fig. 3).

Soft muscular tissue, as is true in the case of soft plant tissue, has very flat ascending stress-strain curves. The modulus of elasticity of the muscle investigated, 5.0×10^8 dynes/cm^2, is small. One third of the curve corresponds to the range of elasticity. Such high elasticity is to be expected for muscular tissue because a stimulated muscle in a state of elastic tension effectively contracts. Breaking stress has the very small value of 20.7 kg/cm^2 (average of measurements).

b. Tendon of Chicken Leg

The stress-strain curve of tendons is probably S-shaped (Fig. 7). The initial part of the curve as drawn is hypothetical, but it is probable that there is a very small elastic range as compared with the great non-elastic range. The stress-strain curve for a tendon is steep. The modulus of elasticity of the tendon investigated is 33×10^8 dynes/cm^2. This value is between the values of *Brasenia* and roots of *Rhus glabra* (wood) but the range of elasticity on the curve is much smaller for tendons than for the plants mentioned. Thus tendon, which is harder tissue than muscle, has a small elasticity. The breaking stress of tendon has the great value of 459 kg/cm^2. It is of physiological importance that tendon as connecting link between muscle and bone has but little elasticity and has a high breaking stress.

c. Plain Catgut

Catgut is a strip of sheep intestine. By investigating catgut, the stress-strain curves for such intestines are found. The stress-strain curve is distinctly S-shaped (Fig. 7). The initial part of the curve has the same shape as the muscle curve (Fig. 3), and the end part of the curve is similar to the tendon (white connective tissue) curve (Fig. 7). These agreements correspond to the fact that cross sections show intestine to consist of muscular tissue and white connective tissue (9).

The modulus of elasticity is 200×10^8 dynes/cm^2, the greatest value which we found for living tissue. The elastic part of the curve is very small as compared with the non-elastic part, and hence intestine has small elasticity. At the boundary of elasticity there is a stress of 306 kg/cm^2 (average value of measurements) and a strain of 0.015. The breaking stress is 1673 kg/cm^2, which is a very high value. (Breaking stress for copper wire is about 6000 kg/cm^2.) Plain catgut is used by physicians for uniting the edges of a wound. Its small elasticity, therefore, and the large value of stress at the boundary of elasticity, and the high breaking stress are very important for its practical application.

d. Stress-strain Curves for Different Animal Tissues

From Fig. 7 and 3, we see that for animal tissue the stress-strain curves are S-shaped curves, or ascending curves. The ascending curve may be considered as a special case of the S-shaped curve.

Elastic plant and animal tissues have the same S-shaped stress-strain curves. These curves are flat for soft plant and animal tissue, steep for hard plant and animal tissue. A similar law is valid for the S-shaped stress-strain curves of rubber (8, p. 518, 3). In 1868 E. J. Marey found the stress-strain curve for the living muscle of a frog (10). Marey's curve is the reflected image of our S-curves. If Marey's curve is correct then the difference of shape as compared to our curves may be explained because the frog muscle was living and our investigated muscles were probably only fresh. It is well known that a fresh frog muscle is living because it distinctly shows contraction after stimulation. Generally this effect is not observed in fresh muscles of warm blooded animals.

V. Equations of the Stress-Strain Curves of Living Tissues

a. S-shaped Stress-strain Curve

In developing the mathematics of the S-shaped curve some assumptions are necessary. From experience it is known that the in-

crement of strain dx is proportional to increment of stress dy. The S-shaped curve (Fig. 9) does not have the slope dy/dx equal to k. So we make the simplest assumption, dx is proportional to dy and also to x. Then dx will be very small near the origin as Fig. 9 demands. Reasons of symmetry demand that we assume dx to be proportional to (L—x) where L is breaking strain. Then dx is very small near the end of the curve as Fig. 9 demands. Hence the differential equation for the S-curve is

$$dx = k \cdot x\ (L - x) \cdot dy \qquad (1)$$

From Fig. 9 is found that the center of the curve is (L/2, S/2) where S is the breaking stress. (y is the independent variable, x is the dependent variable.)

$$dx/dy = k\ x \cdot (L - x)$$

By differentiation

$$d^2x/dy^2 = k^2 \cdot x \cdot (L - x)\ (L - 2x)$$

When $x = L/2$, then $L - 2x = 0$ and $d^2x/dy^2\Big]_{x=L/2} = 0.$

At the center of the S-curve, therefore, the curve has a point of inflection. We integrate the differential equation (1)

$$\frac{dx}{x\ (x - L)} = -k \cdot dy$$

$$\left\{\frac{-1/L}{x} + \frac{1/L}{x - L}\right\} dx = -k \cdot dy$$

$$1/L \cdot \left\{-\frac{dx}{x} + \frac{d(x - L)}{x - L}\right\} = -k \cdot d\,y$$

$$-\ln x + \ln(x - L) + \ln C = -L\,k\,y$$

$$\ln\frac{C \cdot (x - L)}{x} = -L\,k\,y$$

If set $L\,k = m$, then

$$\frac{C \cdot (x - L)}{x} = e^{-m\,y} \qquad (2)$$

Since $x = L/2$, $y = S/2$ is a point of the curve we have

$$\frac{C \cdot (L/2 - L)}{L/2} = e^{-m \cdot S/2}$$

$$C = e^{-m \cdot S/2} \qquad (3)$$

Substituting (3) into (2) gives

$$\frac{-e^{-m \cdot S/2}\ (x - L)}{x} = e^{-m\,y} \qquad (4)$$

$$\ln (x/L-x)=m\,(y-S/2) \qquad (4')$$

and (4) or (4′) is the equation of the S-curve.

Let us now take a new system of coordinates (x′, y′) of parallel axes with the new origin 0′ at x=0 and y=S/2. Hence we have

$$x=x',\ y=S/2+y' \qquad (5)$$

Substituting (5) into (4): $\dfrac{-e^{-m\,.\,S/2}\,(x'-L)}{x'}=e^{-m\,.\,(S/2+y')}$

$$-(x'-L)/x'=e^{-m\,y'}$$

$$-(x'-L)=x'\,e^{-m\,y'}$$

$$x'\,(1+e^{-m\,y'})=L$$

$$x'=L\,.\,1/1+e^{-m\,y'}$$

This is the equation of the S-curve in the system (x′, y′) of coordinates.

It is easily proved that the curve represented by this equation has x′=L/2, y′=0 as center.

For point (x′, y′) of curve (Fig. 9) in the system (x′, y′)

$$x'=L\,.\,\frac{1}{1+e^{-m\,y'}}$$

$$x'=L/2+\left\{L\,.\,\frac{1}{1+e^{-m\,y'}}-L/2\right\} \qquad (6)$$

Then the abscissa x″ of curve point (x″, —y′) in system (x′, y′) is to be computed (Fig. 9). Using the curve equation we get

$$x''=L/2-\left\{L\,.\,\frac{1}{1+e^{-m\,y'}}-L/2\right\} \qquad (7)$$

From (6) and (7) we see that in system (x′, y′) point (x′, y′) and point (x″,—y′) are symmetrical with respect to point (L/2, 0). The point of inflection is the center of the S-curve.

Now we want to show that the stress-strain C-curve which we found by experiment for stems of *Brasenia Schreberi* coincides with the theoretical S-curve. In Fig. 10 the experimental curve is given with the axes x, y and x′, y′. In the system (x, y) is at center x=L/2, y=S/2

$$\left.\frac{dx}{dy}\right]_{\substack{x=L/2,\\ y=S/2}} =k\,.\,L/2\,.\,(L-L/2)=m\,.\,L/4$$

Because of the experimental curve of Fig. 10 we assume that the

breaking strain L=0.06, and the breaking stress $S=13 \times 10^7$ dynes/cm^2.

From Fig. 10 we find at the inflection point of the experimental curve

$$\left.\frac{dx}{dy}\right]_{x=L/2,\, y=S/2} = \frac{0.014}{1 \times 10^7}. \qquad \text{Then}$$

$$0.014/10^7 = m \,.\, 0.06/4$$

$$m = \frac{4 \times 0.014}{0.06 \times 10^7} = 0.93 \times 10^{-7}$$

So the equation of the theoretical S-curve in system (x', y') is

$$x' = L \,.\, \frac{1}{1 + e^{-0.93 \times 10^{-7} \times y'}}$$

By computing the values of x' corresponding to different values of y' we get the table of values below:

y' dynes/cm^2	$y = (S/2 + y')$ dynes/cm^2 $y = (6.5 \times 10^7 + y')$ dynes/cm^2	x
-6.5×10^7	0	0
-5×10^7	1.5×10^7	0.001
-4×10^7	2.5×10^7	0.001
-3×10^7	3.5×10^7	0.003
-2×10^7	4.5×10^7	0.008
-10^7	5.5×10^7	0.017
0	6.5×10^7	0.030
10^7	7.5×10^7	0.043
2×10^7	8.5×10^7	0.052
3×10^7	9.5×10^7	0.056

By drawing the points (x, y) of this table we get the theoretical S-curve in Fig. 10.

The general shape of experimental and theoretical curves is the same. There is a very good coincidence of both curves in the upper part, but some deviation in the lower part (Fig. 10). There must be some deviation because the theoretical curve is symmetrical, and the experimental curve is non-symmetrical. Elastic and non-elastic parts of the experimental curve have more or less different shapes. The equation derived is only correct if the point of inflection and the center are about the same.

b. Ascending Stress-Strain Curve

According to our measurements the breaking strain L is not very large, but the point corresponding to L is on the horizontal part of the ascending curve (Fig. 11). A small change of stress in the horizontal part of the curve produces very great change of strain; so L may be much larger than measurements indicate.

We may assume L is very large, then $(L—x)$ in differential equation (1) is essentially constant for small values of x. Hence for ascending stress-strain curves we may have the differential equation

$$dx=k \cdot x \cdot dy$$

After integrating it is found that theoretical and experimental curve do not coincide, so we may assume dx is not proportional to x, but to y. Then the differential equation for the ascending stress-strain curves is

$$dx=k \cdot y \cdot dy \qquad (8)$$

We integrate $x=k \cdot y^2/2+C.$

When $x=0$, $y=0$ (see Fig. 11), then $C=0$.

$$x=k \cdot y^2/2, \text{ or}$$

$$y^2=k'x \qquad (9)$$

which is the equation of a parabola.

The parabola is the theoretical stress-strain curve for plastic bodies (5). In III,a, we assumed that there may be a connection between ascending stress-strain curves for elastic living tissues and stress-strain curves for plastic bodies. It will be found that the parabola has about the shape of the experimental ascending stress-strain curve (Fig. 11) for petioles of *Nymphaea* or muscles of the rooster wing. The deviation of both curves generally is not more than 15% for given values of x.

By using the experimental curve in Fig. 11 we may find k′. For point $x=0.02$, $y=10^7$ dynes/cm² we have

$$10^{14}=k' \times 0.02$$

$$k'=10^{14}/0.02=50 \times 10^{14} \qquad (10)$$

Substituting (10) into (9): $y^2=50 \cdot 10^{14} \cdot x$

which is the equation of the theoretical stress-strain curve in the case of petioles of *Nymphaea*.

By computing the values of y corresponding to different values of x we get the table of values:

x	y dynes/cm²
0.004	0.4×10^7
0.01	0.7×10^7
0.02	1.0×10^7
0.03	1.22×10^7
0.04	1.41×10^7
0.05	1.58×10^7
0.06	1.73×10^7
0.07	1.87×10^7
0.08	2.0×10^7
0.09	2.1×10^7
0.10	2.2×10^7
0.12	2.4×10^7

By drawing the points (x, y) of this table we get the theoretical ascending curve in Fig. 11.

c. Straight Line as Stress-Strain Curve

According to Hooke's Law for metallic rods the elastic part of the stress-strain curve is a straight line. So for the elastic part of the curve we get

$dx = k \cdot dy$ (differential equation of straight line),

$$\text{hence } x = k \cdot y + C$$

Since $x=0$, $y=0$ is a point of the line, then $C=0$.

$$x = k \cdot y \text{, or } y = k' x$$

is the equation of the straight line which is stress-strain curve.

d. The Differential Equations of Stress-Strain Curves

The differential equation of the S-shaped curve

$$dx = k \cdot x \cdot (L - x) \cdot dy$$

is the general case.

By setting $(L-x)=$constant and replacing x by y we get the differential equation of the ascending curve

$$dx = k \cdot y \cdot dy$$

By setting y equal to a constant in the last equation, we get the differential equation for Hooke's Law

$$dx = k \cdot dy$$

The ascending curve and straight line are therefore special cases of the S-shaped stress-strain curve. Hence by mathematical analysis it is apparent that for different living tissues there is a slow change

from the ascending stress-strain curve to the S-curve and at last to the straight line (Fig. 8).

VI. Gough-Joule Effect in Elastic Living Tissue

William Thomson (Lord Kelvin) discovered that a rubber strip becomes heated when quickly elongated to a considerable extent (8, pp. 412-426). From the laws of thermodynamics he predicted that a stretched rubber strip must shorten when heated. J. P. Joule experimentally verified the prediction of Lord Kelvin. In Joule's classic work of 1859 where the experiment is reported, is a reference to the priority of John Gough, who first studied this peculiar behavior of rubber. In 1805, Gough determined, by touching rubber strips to his lips that the rubber was heated by stretching and cooled by contraction. He also found that a strip of rubber elongated by weight shortens itself when heated and lengthens again when cooled. Gough's observations have remained unnoticed, while those of Joule, whose discovery was independent, have become widely known. This effect observed in rubber is called the Gough-Joule effect.

The same effect is also observed in animal substances. Hill and Hartree showed that a muscle passively stretched becomes heated. O. Meyerhof gives Thomson's formula for the heat produced when a muscle is stretched (11). The elastic fibers from the fins of sharks also shorten themselves by about one-third of their original length in hot water and the elastic tissue of the cervical ligament of cattle shows a similar shortening effect, which is reversible up to a temperature of 60°.

Because there were no experiments proving whether the Gough-Joule effect for rubber is also valid for elastic plant tissue we tried to find the effect by using rhizomes of *Equisetum fluviatile.*

Two kinds of experiments were performed. The general device was the same as in our other experiments (see Part II). The stretched rhizome was covered with gauze, the lower ends of which dipped into hot water. During the experiment hot water was poured over the gauze covering the rhizome.

1. The rhizomes of *Equisetum fluviatile* were collected in Reese's Bog (dry habitat). The result of the measurements were as follows:

Rhizome in initial state without tension has length
a. 12.84 cms b. 20.20 cms

Rhizome stretched with tension has length
a. 13.12 cms b. 20.38 cms

Rhizome stretched with tension in hot water, reading after 3 minutes

a. 13.06 cms   b. 20.28 cms

Hot water removed, reading after 3 minutes for rhizome stretched with tension

a. 13.12 cms   b. 20.38 cms

Rhizome without tension has length

a. 12.84 cms   b. 20.20 cms

Shrinkage effect in a) 0.6 mm; in b) 1.0 mm.

Both experiments show that there is a small shrinkage effect if the stretched rhizome was dipped in hot water. The process here is reversible as is the case for a stretched rubber strip. We see therefore that the Gough-Joule effect takes place in elastic plant tissue.

2. For getting greater effects, in a second series of experiments, we observed only the lengthening when the hot rhizome, elongated by weights, was cooled. Besides the best elastic plant material available, rhizomes of *Equisetum fluviatile* of Marl Bay (wet habitat) were collected. In three experiments the hot rhizome elongated by weights was cooled and the lengthening observed was

a. 1.6 mm,   b. 1.7 mm,   c. 1.8 mm.

which means that the Gough-Joule effect was very distinctly observed.

In a last experiment we also measured the time and temperature for obtaining the best values. The measurement was as follows:

Rhizome at room temperature—17.68 cms.

Stretched by 500 gms—18.14 cms (measured after 3 minutes), hence elastic stretching 0.46 cms.

The same rhizome of length 17.68 cms again (without tension) but now in hot water of temperature 65°C. was stretched by 500 gms. The length observed was 17.88 cms (measured after 3 minutes), hence the stretching was 0.20 cms.

When the rhizome was cooled to 47°C., its length was 18.04 cms. and hence stretching 0.36 cms.

When the rhizome was cooled to room temperature, the length became 18.12 cms and hence the stretching was 0.44 cms. This value checks very well the first value of 0.46 cms.

Rhizome elongated by weights. Cooling from 65° C. to room temperature shows a lengthening of 2.4 mms.; cooling from 47°C. to room temperature shows a lengthening of 0.8 mms. This last experiment makes sure that the Gough-Joule experiment is true for elastic tissue.

From Parts III and IV it is known that elastic living tissue has an S-shaped stress-strain curve similar to rubber, and similar laws are valid for all these substances. The validity of the Gough-Joule effect for rubber, elastic animal tissue, and elastic plant tissue confirms these results.

This latter fact tells us something more for it is now possible to make predictions about the structure of elastic living tissue. The validity of the Gough-Joule effect for rubber was the reason that L. Hock assumed the fiber structure of elongated rubber. Hence we may expect that relaxed elastic living tissue is isotropic, but stretched material is anistropic.

VII. Growth and Stress

Stress and strain are a direct stimulus to growth (12). The soles of our feet grow thick the more we walk upon them, the living cells being stimulated by pressure to increase and multiply. In experiments of Sédillot, the greater part of the shaft of the tibia was excised in some young puppies, leaving the whole weight of the body to rest upon the fibula. The latter bone is normally about one-fifth of the diameter of the tibia; but under the stimulus of the increased load, it grew until it was thicker than the normal bulk of the larger bone.

The healing of a wound bears a close resemblance to growth as a whole. Investigation of the various processes involved has shed considerable light on the mechanics of growth (13).

Leo Loeb and his coworkers have made an extensive study of the healing of a skin wound. They found that if the skin is removed from any spot, epidermal cells from the edge of the wound crept over the denuded spot and formed a covering layer—a surface tension phenomenon. The stretching of the contents of the surrounding cells so produced, causes a rapid series of cell divisions, i.e., growth under stimulation of stress takes place. It is noteworthy that, before normal rate of cell division is resumed, distinct pressure must be exerted by the epithelial cells on one another, and the excessive formation of epithelial cells results. From this and similar experiments it may be assumed that cell pressure is one of the limiting factors of growth.

Not only for animals but also for plants it is known that there is a relation between growth and stress. It has often been observed that tension and pressure have a distinct influence on the growth of plants (14). An increase in growth in the direction of the tension is

to be expected; that such growth takes place is easily proved if a stem is stretched by weight. In ripening fruits the amount and the thickness of mechanical elements increases in proportion to the increase in weight. By bending the main root, development of lateral roots from the concave side may be prevented and they then arise only on the convex or stretched side.

These relations of growth and stress found by experiment are still more obvious if we consider growth curves and stress-strain curves. In Fig. 16 the growth curve of *Lupinus albus* is shown (12, p. 160, Fig. 32). This curve again shows the S-shaped curve which is found for stress-strain curves of elastic living tissue. From Part Va we get by replacing strain x by length x and y by time t, the equation of the growth curve (12, p. 260)

$$(1') \quad dx/dt = k' \, x \, (a - x)$$

(according to Part V a, equation 1)

Integration gives $\ln (x/a - x) = m' \, (t - T/2)$

(according to Part V a, equation 4′)

where a = maximum height of the plant, and T/2 = time when one-half of that height was reached.

The assumption is here made that stress is increasing with the time of growth. Hence time t is proportional to stress y. With this assumption we obtain

$$(4'') \quad \ln (x/a - x) = m'' \, (y - S/2)$$

S = maximum stress.

Similar equations are therefore obtained for growth curves (4″) and for stress-strain curves (Part V a, equation 4′). Hence we may assume that growth is created by stress. This behavior might be in accord with the experiments mentioned concerning animals and plants.

There is a difference, however, between growth curves and stress-strain curves. Growth curves are symmetric with respect to the point of inflection. Stress-strain curves are more or less symmetric because they are composed of the lower elastic part and the upper unelastic part. The common explanation is that growth is an autocatalytic reaction. Hence equation (1′) is valid (12, p. 260).

VIII. Summary

1. The elastic properties of rhizomes of *Equisetum* were found in 1942. (3). This study is an attempt to determine whether there are general laws of behavior for all elastic plant and animal tissues,

and whether the elastic properties of *Equisetum* rhizomes are found in all elastic living tissues.

The experimental device of 1942 was improved but it generally was the same as for the *Equisetum* experiments.

2. Values of the modulus of elasticity, of stress and strain at the boundary of elasticity, of breaking stress and breaking strain are given below:

Material	Modulus of elasticity dynes/cm²	At Boundary of Elastic. stress kg/cm²	strain	Breaking stress kg/cm²	Breaking strain
Vulvanized rubber	0.078x10⁸	....	.. ..	....	.. ..
Rhizomes of Equisetum fluviatile	4.1 x10⁸	....	.. ..	124.5	0.472
Petioles of Nymphaea tuberosa	5.0 x10⁸	12.2	0.024	20.4	0.12
Muscles of rooster wing	5.0 x10⁸	....	.. ..	20.7	.. ..
Stems of Brasenia schreberi	28.5 x10⁸	53.1	0.020	81.6	0.05
Tendon of chicken leg	33 x10⁸	....	.. ..	459	.. ..
Wood of roots of Rhus glabra	54 x10⁸	131.6	0.025	282.6	0.08
Sclerenchym. pl. of Pteris aquilina	115.9 x10⁸	....	.. ..	704	.. ..
Intestine of sheep	200 x10⁸	306	0.015	1673	.. ..
Steel	20000 x10⁸	....	.. ..	....	.. ..
Copper wire	....	....	.. ..	6000	.. ..

We conclude for living tissue that the elasticity of an object is inversely proportional to the modulus of elasticity.

3. Elastic plant and animal tissue have S-shaped stress-strain curves similar to rubber. These curves are flat for soft or lightly built plant and animal tissues, steep for hard or heavily built plant and animal tissues.

Ascending curves for elastic living tissue may be considered as S-curves with the superior part at infinity.

4. Elastic soft living tissues are very elastic (small modulus of elasticity); elastic hard living tissues are less elastic (great modulus of elasticity). Some metals and rubber exhibit the same behavior.

5. For different elastic living tissues there is a slow change from the S-shaped stress-strain curve to the straight line behavior; from rubber elasticity to metallic elasticity.

6. By the Gough-Joule effect, a stretched rubber strip must shorten when heated and must lengthen when cooled. The same effect was observed for elastic animal tissue.

By using the very elastic rhizomes of *Equisetum fluviatile* we found that the Gough-Joule effect is also valid for elastic plant tissue.

7. S-shaped stress-strain curves and Gough-Joule effect give proof for the similarity of elasticity of living tissue and the elasticity

of rubber. It may therefore be true that there is a similarity of structure of rubber and elastic living tissues (3).

8. The differential equations for stress-strain curves are

(1) $dx = kx\,(L - x)\,.\,dy$ (S-shaped curve),

(2) $dx = ky\,dy$ (ascending curve),

(3) $dx = k\,d\,y$ (straight line),

where

dx=increment of strain,
dy=increment of stress,
x=strain,
y=stress,
L=breaking strain, k=constant.

The equation of the S-curve found by integration of (1) is

$$\ln\,(x/L - x) = m(y - S/2)$$

where S=breaking stress, m=constant.

It was proved that there is coincidence between experimental and theoretical S-curves.

The equation of the ascending stress-strain curve found by integration of (2) is

$$y^2 = k'\,x,$$

where k'=constant.

The parabola is a theoretical stress-strain curve. It was also proved that there is a fairly good coincidence between experimental and theoretical ascending stress-strain curves.

The equation of the elastic part of the stress-strain curve for metal rods found by integration of (3) is

$$y = k''\,x,$$

where k''=modulus of elasticity.

This is the equation of a straight line (Hooke's Law). The similarity of differential equations (1), (2) and (3) checks the experimental fact that there is a slow change from the ascending stress-strain curve to the S-curve and at last to the straight line.

Rubber elasticity and metallic elasticity are connected by intermediate links.

9. Many experiments show that there are relations of growth and stress. These relations are still more obvious because stress-strain curves for living tissues and growth curves of animals and plants are both S-shaped.

The equations of both kinds of curves are very similar. In addition, the velocity of an autocatalytic reaction also follows an

equation similar to that of the growth curve. Hence we conclude that growth is a biological phenomenon whose physical part may be explained by using stress and whose chemical part may be explained by using autocatalytic reactions.

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An Extreme Case of Scaphocephaly From a Mound Burial Near Troy, Kansas

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Introduction

The skull which is the subject of the present paper attracted the attention of the writers when they noticed it in an exhibition case in Dyche Museum at the University of Kansas. A check of the records revealed that it was collected many years ago by Dr. R. S. Dinsmore from a burial mound near Troy, Kansas. Unfortunately, no additional archeological information is available, due to the early date at which the skull was obtained. Since it came, however, from a mound on the Missouri River bluffs, it quite possibly belongs to the Woodland Cultural Pattern, regarded by archeologists as flourishing in this particular region some time in the neighborhood of 1300 A. D. ([1])

The skull had been described in the records as "artificially deformed," but since, instead, it obviously presented a marked case of scaphocephaly, it seemed well to put a description of the skull on record. In spite of many references to scaphocephaly in both anthropological and medical literature, the subject has been briefly and inadequately treated, particularly in regard to certain endocranial features of which this specimen is a beautiful example. Cranial conditions which, to the anthropometrist are distinct entities, are not clearly differentiated by many medical writers. Moreover, it is rarely that such an ancient cranium, in perfect condition, falls into the hands of both physician and anthropologist. The writers are intent upon (1) offering a description of this skull which will furnish some adequate data, both metric and morphological upon a subject which, while often mentioned, has not been very systematically explored in recent years, and, (2) discussing the specimen in relation to the various theories held, showing wherein it appears to support one or another of them. Moreover, as mentioned previously, there has been a dearth, if not an actual lack, of adequately described specimens. It is our hope that when more records of such cranial anomalies are available, their nature may be more fully understood. Thanks to the generous co-operation of Dr. Claude Hibbard of the

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University of Kansas Museum, this skull has been made available to us for study. We should also like to express our appreciation to Dr. W. R. Wedel of the U. S. National Museum for advice upon certain matters pertaining to its cultural provenience.

II. Description

Scaphocephaly is generally defined as that cranial condition in which, due to premature synostosis of the sagittal suture, skull growth is magnified antero-posteriorly rather than transversely. The result is an ultradolichocephalic skull, narrow and long and lacking parietal tuberosities. The skull vault slopes quickly away from a keel-like median sagittal line. Nevertheless the cranium remains bilaterally symmetrical because of the longitudinal nature of the growth process to which the other bony elements of the skull adjust.

The present specimen is that of a mature female of approximately 30 years of age. The skull is ultradolichocephalic, gracile, and completely feminine in character. Supra-orbital ridges are en-

Measurements of Skull No. 3934, University of Kansas Museum

All measurements in millimeters

*Length	194	Auricular height	121
*Breadth	121	Circumference	511
Bizygomatic width	128	Transverse arc through vertex	285
Minimum frontal width	91	Total sagittal arc	387
Interangular width	100	Frontal arc	122
Upper face height	64	*Parietal arc	135
Total face height	103	Occipital arc	130
Nasal height	45	Frontal chord	107
Nasal width	24	*Parietal chord	126
Alveolar length	53	Occipital chord	104
Alveolar width	65	Orbital height	R.33—L.35
*Biasterionic width	99	Orbital width (dacryon)	R.31—L.40
*Width at stephanion	99	Foramen magnum length	34
Basi-bregmatic height	139	Foramen magnum width	28
Basion-nasion	103	Bicanine breadth	40
Basion-prosthion	95	Bimolar breadth	63
Cranial capacity by Pearson's interracial total ht. formula	1306cc.		

Indices

Cranial module	151.	Height-Length index	71.64
*Cranial index	62.3	*Breadth-Height index	114.8
Superior facial index	50.	Cranio-facial index	71.92
Maxillo-alveolar index	122.	*Transverse cranio-facial index	105.78
Nasal index	53.33	Facial module	108.6
Foramen magnum index	82.35	Gnathic index	92.3
Total facial index	80.4	Intertemporal-Interangular index	91.
Auricular height-length index	62.37		
Bicanine index	63.49		

*The measurements and indices marked by an asterisk are those which reveal most clearly the influence of scaphocephalic distortion.

MANDIBLE

Bimental breadth	46	Symphyseal height	29
Minimum width ascending ramus	33	Bigonial width	97
Bicondylar width	114	Length	100

tirely lacking, and there is only a faint trace of a glabellar prominence. The sagittal suture is entirely synostosed and obliterated, although the coronal suture is still open ectocranially throughout its length except, on each side, for a very small area at stephanion.

The parietal foramina are lacking. There is a slightly flattened and depressed area in the region of the obelion and the superior border of this region carries two rather pronounced bosses arranged symmetrically, one on either side of the obliterated suture, and placed close together. The possible significance of these two bosses will be discussed at more length later.

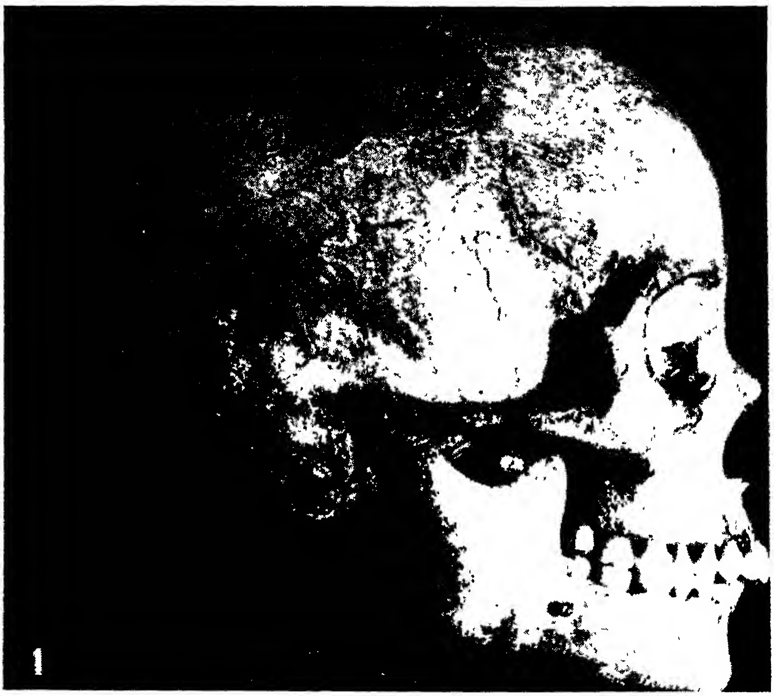

PLATE I—Norma lateralis.

The occiput is narrow and protruding. The *planum nuchale* is smooth and shows little muscular relief or rugosity. Both the superior and inferior nuchal lines are only faintly visible. The external

occipital protuberance is entirely lacking, but the *crista occipitalis externa* is faintly evident. The gracility and lack of ruggedness of the whole nuchal area is suggestive of the distinctly feminine nature of the calvarium. The zygomata are slender and delicate. In spite of the narrow skull vault, there is only a hint of phaenozygosity.

The mastoid processes are the shortest and most blunt the writers have ever seen in an adult human skull. The tips do not project beyond the *pars lateralis* of the occipital bone. The glenoid fossae are small and shallow but in no way abnormal.

The face is short, the frontal angle high, with a full and prominent forehead. The nasal root is low but not pronouncedly so. The nasal index is platyrrhine. There is a nasal spine of medium length and the nasal sill is short and well defined. The canine fossae are slightly evident. The upper incisors show the "shovel-shaped" condition so typical of Mongoloids, and there is a rather marked degree of overbite. The dentition is almost perfect. There is evidence of only moderate wear and the loss of a single tooth—a first left premolar—during life. The third molars have all erupted properly, and there is only one cavity—a large one—in the left lower second molar.

The optic foramina are more oval than round, as if compressed from side to side. The superior and inferior orbital fissures seem narrower than usual; the greater wings of the sphenoid appear to have encroached on them laterally.

The body of the mandible is, transversely, rather thick and stocky, particularly in the molar region, but is in no way remarkable. Both mental foramina, however, are very small, almost abnormally so. They lie beneath the second premolar. The lingula overlying the mandibular foramen is unusually thick and blunt. The basilar aspect of the skull presents little in the way of unusual features except the slightly drawn out aspect of the foramen magnum, apparently in response to the unusual rearward protrusion of the occipital bone. A pharyngeal fossa replaces the tubercle of that name, but there is a rather high incidence of this anomaly among Amerinds.

Barring the premature ossification of the sagittal suture, there is little of an unusual nature to be noted about cranial closure. The coronal suture is pronouncedly complex in the region overlying stephanion and the lambdoid similarly throughout its biasterionic portion. No Wormian bones were noted. The H form of pterion characterizes both sides of the vault.

Examination of the inner anatomy of the skull is limited to information which can be gained by inspection and palpation through

the foramen magnum, since the skull is not sectioned.

The inner table of the bones of the vault is intact; an unusual series of markings is seen on all visible bony surfaces. These markings are palpable on the occipital bone. They are less marked on the calvarium than nearer the base of the skull, where they assume the form of shallow broad grooves separated by low crests of bone. The irregular pattern, breadth and depth of groove, and form of the ridged boundaries follow the pattern of cerebral convolutions and undoubtedly represent "convolutional atrophy," also known as "digital impressions." Their significance will be indicated later.

The vascular markings are of special interest. The anterior and posterior branches of the middle meningeal artery are prominently represented down to very small rami. Lying directly in line with the fused sagittal suture is a groove of varying breadth (estimated 3 to 6 mm.) and of a depth unknown in the experience of the authors. Starting as a shallow impression anterior to the coronal sulcus, it deepens rapidly until at the torcular Herophili (sinus confluens) it is so deep that the palpating finger may not be pressed against its bottom. At this latter point it turns to the right. This groove follows the course of the superior sagittal sinus. Bilaterally the transverse sulcus is easily palpated in the rim of the posterior cranial fossa, at first shallow posteriorly but deepening as the palpating finger follows it laterally and anteriorly. Parasagittally, at about vertex and just anterior to the coronal sulcus, irregular pits and depressions are seen bilaterally which suggest the Pacchionian markings.

No endocranial marking may be distinguished in the region of the pair of eminences referred to ectocranially as lying near the obelion.

The sella turcica and hypophyseal fossae do not seem enlarged or altered in shape. The anterior and posterior clinoid processes on the right are fused to form a bony bridge.

The sagittal suture is completely fused throughout its visible length. The coronal suture is open endocranially, except in its most lateral aspects; however, no light is transmitted through it. The visible portion of the squamosal suture is open.

In no place does light thrown into the skull trans-illuminate the calvarium. Neither frontal nor maxillary sinuses trans-illuminate.

A table of anthropometric data is given. It will be noted that all of the measurements which are in the least unusual pertain to the excessive longitudinal growth of the parietal, largely in a posterior

direction, and the necessary adjustments made by the other bones to the narrowed vault. Such an index as the transverse cranio-facial,

PLATE II—Norma verticalis.

PLATE III—Norma basalis.

for example (105.78) is of a noticeably primitive character because of the narrowness of the vault in comparison with the zygomata. We have starred in the above tables certain indices which reflect the nature of the pathology. The basilar region of the skull anterior to the foramen magnum seems less affected, in terms of width, than the drawn-out occiput. This difference can be noticed in the photographs and is also reflected in the low biasterionic width of 99 mm. The skull gives an appearance of complete bilateral symmetry and adjustment despite its obviously pathologic nature.

III. Etiology

Dye and Kinder have commented that: "Of the factors which have been considered important in determining the shape of the skull, the following may be mentioned: 1) intelligence, 2) brain development, 3) growth of sinuses, 4) heredity, 5) growth of sutures, and 6) muscle development and muscle pull or pressure. No two investigators will give quite the same importance to each of these factors."(2) From the information available on examination of the Troy skull, it is possible to comment primarily only on the fifth and sixth of these, and incidentally on the second and third.

One of the most conspicuous, and perhaps fundamental, deviations from normal in this cranium is the complete fusion of the sagittal suture. Bonnet has classified suture closure according to the time at which it occurs with reference to brain growth. As quoted(3) he lists:

1. Premature synostosis, where closure occurs before full brain growth is reached.
2. Synostosis praecox: suture closure after complete brain growth but before normal obliteration.
3. Senile suture obliteration; a normal phenomenon of middle age and later.

With respect to age groups in the human being, it may be remarked that brain volume at birth is about 330 c.c.; at one year of age, 950 c.c.; average adult brains vary around approximately 1450 cc. as a norm, over 1300 cc. of this increase being achieved by the age of ten years.(4) The age-group twenty-six to thirty is the elective period for suture obliteration, both ecto- and endo-cranial.(5)

Increase in brain volume is seldom inhibited by the occurrence of premature synostosis. Adequate cranial capacity is provided by continued bony growth, but the shape of the cranium and its contents may be altered. If two cranial bones undergo premature bony union, the normal lateral growth of bone will be inhibited in a direction which is perpendicular to the obliterated suture line (since it is at the non-fused bony margins that growth normally occurs) and the compensatory growth will occur in other directions. The nature and amount of deformity will be a function of three factors: 1) the sutures which fuse; 2) the completeness of the fusion; and 3) the amount of brain growth which follows the fusion.

In intramembranous osteogenesis (the type of bone formation in the skull vault) the advancing bone edge is preceded by osteoblastic activity in a fibrous connective tissue membrane of the collagen-

ous variety. When bone from two adjacent centers of ossification approaches a juncture, synostosis is prevented for a time by continued new formation of this "membrane," thus maintaining the classic articulation known in arthrologic terminology as "suture": a union of skeletal elements by a continuous intervening layer of fibrous connective tissue. When synostosis occurs, it is not so much a positive phenomenon on the part of bone as it is a failure of this fibrous connective tissue to maintain its interposition by continued replacement of itself.

The etiologic theories which have been based on premature synostosis revolve about three main ideas:

1) Virchow's concept of some inflammatory process in the fetal cranium which deprives the bone margins of their normal growth potential and possibly, due to the fact that calcification is not an unusual sequela of inflammation, promotes the suture closure.

2) A defect in the blastemal skeleton, perhaps as a result of a congenital abnormality in the interstitial mesenchyme, or from injury in very early embryonic life. On the basis of such considerations as the occasional association of syndactylism with skull deformity, it is believed that the mesenchymal abnormality must date from earlier than the seventh week of embryonic life.

3) Displacement of primary ossification centers of the synostotic bones toward each other. Cases have been reported in which the ossification centers of separate bones were merged into one common center in the fused suture.

Another set of theories of the origin of these skull deformities is founded not on premature synostosis as primary, but on localized changes in the skull. Two such concepts are:

1) Defects in the sphenoid bone. Scaphocephaly has been noted very frequently in connection with underdevelopment of the greater wings of the sphenoid; the oxycephalic (or "steeple-skull") deformity, concersely, is often associated with abnormally large greater wings. Ogilvie and Posel([6]) describe cases in support of the concept that the primary defect is basilar, with consequent alterations in shape of the brain case to accommodate the broader or narrower sphenoid.

2) Generalized basilar hypoplasia. Gunther is quoted([3]) as stressing the importance of such developmental

failure, the mechanism of production of deformity possibly being related to disturbances in blood supply to the developing bones of the calvarium, resulting from narrowing of the basal vascular foramina. The hypothesis, attributed to Broca, that an abnormally shaped brain is the primary cause of deformity is receiving very slight attention at present.

Very few studies on pathology are available. Of cases diagnosed while living, roentgenographic studies furnish the only information to supplement that gained from inspection, palpation, and craniometry. There are obvious difficulties involved in following such cases to an autopsy so complete that the skull is examined freely. On the other hand, the occasional diagnosis made on skulls from osteologic collections is very infrequently accompanied by any data regarding soft-part anatomy or symptomatology and functional defect during life. Of the case here presented, no such data are available save by implication.

Classifications of this group of skull deformities reveal the difference in emphasis from the standpoint of the physician or the physical anthropologist. When described at all in the medical textbook, seldom is any term except oxycephaly applied. Although there is general agreement as to the appearance of the deformity, such emphasis seems to result from the clinical impression that this skull type of all the group, is the most productive of spectacular symptomatology. Greig's([11]) classification may be representative: when synostosis involves all the sutures of the head and face, we have true oxycephaly; with one or a few synostosed sutures, the term pseudo-oxycephaly may be applied. Greene and Brown ([7]) observed synostotic deformities in the rabbit which, although they are not maintained to be identical with those in man, have a great deal in common with them (including, probably, mode of origin). Greene's specific definitions ([8]) of the deformities should be of value in clarifying classification systems; they are repeated here.

1. Scaphocephaly is used in reference to the deformity resulting from fusion of the sagittal suture.
2. Plagiocephaly refers to that deformity resulting from fusion of a single segment of the coronal, right or left.
3. Trigonocephaly refers to fusion of both coronals.
4. Oxycephaly refers to fusion of the sagittal and both coronal sutures.

In oxycephaly the synotosis may or may not involve the entire suture, where elevated bony ridges mark the line of fusion. Diploic tissue is scanty, and the inner table of bone may be absent through pressure atrophy. Characteristic is the "convolutional atrophy" of the endocranium, in which shallow bony grooves afford a map of the gyri and sulci of the cerebral cortex. The cranial base is hypoplastic and depressed, with middle and posterior fossae especially deep and foreshortened. Sella turcica and hypophyseal fossae are usually unaltered. The sphenoidal greater wings are often unusually large. The face may be broadened; orbital foramina are occasionally narrowed. Radiographically the paranasal sinuses are often small or absent.

Scaphocephaly differs from oxycephaly only in two essential respects: the shape of the head and the less extensive resultant deformity. The sagittal suture is primarily involved, with a narrow skull devoid of parietal eminences. The convolutional atrophy and thinning of the skull is present as in oxycephaly; orbital change is inconstant. A change rather constantly remarked is the hypoplastic state of the greater wings of the sphenoid bone.

Defects most constantly associated with premature synostosis include syndactylism, polydactylism, joint structure ankylosis and deformity (most commonly of the elbow), hemolytic icterus, and vascular anomalies. The relationship of all of these conditions to the mesenchyme has been pointed out as evidence in support of an interstitial mesenchymal etiology.

Deviations from normal range of skull anatomy in the present specimen requiring comment in view of the foregoing etiologic and pathologic generalities follow.

The fusion of the sagittal suture is complete, involving both inner and outer table, throughout the length of the suture. That this suture closure is intimately related to the classic scaphoid form of the cranium is demonstrated by examination of indices $\frac{\text{chord} \times 100}{\text{length}}$, where the chord is measured antero-posteriorly over the surface of the bone concerned and the length is nasion-basion. For the sagittal chord, this index is 64.4, a distinct elevation over normal range. The frontal, with its index similarly computed, is low with 55.1, while the occipital bone is within normal range for dolichocephalic skulls with 53.6. The bony disproportion is, therefore, especially marked in terms of parietal bone elongation and (compensatory ?) frontal bone foreshortening.

The two prominences near obelion, close to the sagittal suture

and lying almost midway between lambda and bregma, are of special interest in relation to the theory that premature synostosis is a result of displaced ossification centers. Martin says of scaphocephaly: "The ridge or keel-shaped elevation of the cranium (culmen cuneiforme) is brought about through a smoothing-out of the parietal bones, and has origin in the synostosis of the sagittal suture, usually beginning in the fetal period in the region of obelion and completed within the first decade of life."([9]) In the absence of the usual parietal eminences the masses indicated may represent the displaced center; in this skull they attain a prominence not described specifically to our knowledge. Their presence does not invalidate the theory based on abnormality of the interstitial mesenchyme; a defect in the germinal tissue separating the two ossification centers would account for their displacement toward each other. The flattened, depressed area between them may be of interest from this aspect.

In view of the prominence attached to the sphenoid bone in etiological hypotheses, it is surprising that the sphenoid of this specimen does not appear to deviate markedly from normal. In the absence of metric criteria of sphenoid form, this observation, as also those in the literature, must remain only an impression.

The appearance of constriction and hypoplasia of the basilar foramina does not necessarily establish evidence for the basilar hypoplasia theory of etiology, since the anomaly could be secondary to vault changes. In Greene's ([7]) craniostotic rabbits, the base of the skull (including the sphenoid) was still cartilaginous while suture union of the calvarium was being established (as early as the third week of embryonic development). The narrowing of the foramina does, however, have special interest in attempting to account for the anomaly remarked in the next paragraph.

The endocranial groove for the superior sagittal and portions of the transverse sinuses is markedly deepened. This deepening is of more interest from the standpoint of bone formation and mechanics than etiology. If the narrowing of foramina around emergent channels should have impeded the normally free outflow of blood, it may be hypothecated that the pressure of blood within the dural sinuses rose. No great pressure differential is needed to account for bone erosion and resorption; Policard has emphasized to the contrary that "very weak pressures are capable of provoking absorption"([10]). The continuous application of the pressure is a necessary condition. It would be possible to lay less emphasis on the venous sinus pressure here if the sagittal sinus alone were involved, in which case the

groove might be more directly related to synostosis of the overlying suture. With the involvement of the lateral aspects of the transverse

Plate IV—Norma frontalis.

Plate V—Norma occipitalis.

sinus, however, and the great depth of the torcular Herophili, a more generalized explanation is needed.

The convolutional atrophy, as well as meningeal vascular markings, on the inner table of the skull agrees with previous descriptions, and has been accounted for by the suggestions of increased intracranial pressure. The mechanism of this atrophy is not clear; the accuracy of reproduction of gyri and sulci would seem to require a reduction in the amount of fluid in subarachnoid spaces, such that brain tissue might press directly against bone. It is even more remarkable to note that convolutional atrophy is a frequent finding, while clinically patients seldom show convulsions or epilepsy. The brain cortex, while highly sensitive to pressure, seems yet not so sensitive to continuous minute pressure elevations as is the bone covering it; here again, evidence is afforded for the general concept of the great plasticity of bone.

The bridging of the clinoid processes has not been recorded as a part of the syndrome. Although it is probably an incidental finding here, it should be noted that clinoid abnormalities are not unknown. The oxycephalic and plagiocephalic rabbits studied by Greene showed the posterior clinoids to be slightly longer and directed more laterally than normal. No attempt to relate these observations can be made at present.

The mastoid hypoplasia is, like the clinoids, not described as a concomitant deformity in scaphocephaly. If re-examination and future experience should establish it as a part of the characteristic syndrome, it would appear preferable not to interpret it in terms of primary or etiologic significance. Although no data for an analysis of musculo-skeletal mechanics can be had for the present specimen, the following line of speculation is of interest. Traction has a predominant effect on the determination of number and arrangement of osteoid fibrils. ([10]) The mechanism is physico-chemical, possibly by orienting the colloidal micellae of the collagenous substance in the direction of line of traction (similar to orientation in India rubber and in photo-plastic substances). The mastoid process is a traction apophysis, and its development and size are dependent on the activity of the sterno-cleido-mastoid muscle, much of which attaches to it. In man, the sterno-cleido-mastoids, acting bilaterally, cause the head to tilt forward; with hyperextension, they may increase the upward and backward tilt. (This potentially double activity is, of course, a result of their attachment on to the mastoid processes at a site almost directly in line with the axis about which the nodding movement

occurs.) If, through the distortion of the scaphocephalic head, normal distribution of forces should be shifted on the anterior and posterior arms of the lever whose fulcrum is at the occipital condyles, it is conceivable that less power might be required of the sterno-cleido-mastoids in moving or fixing the head, with resultant diminution of the traction force on the mastoid site of attachment. In support of this relationship of sterno-cleido-mastoid muscle to mastoid process, three types of mastoid hypoplasia not associated with synostosis may be cited:

1. Cleido-cranial dysostosis, in which (with clavicular aplasia) there is a lack of formation of the cleido-mastoid portion of the sterno-cleido-mastoid muscle. Greig's case shows an absence of the mastoid processes. ([11])
2. Purves-Stewart's case showed an association of unilateral absence of the sterno-cleido-mastoid with absence of the corresponding mastoid process. ([12])
3. In torticollis, or "wry-neck," the mastoid processes are asymmetrical; the larger process is that to which the contracted muscle attaches.

The anomalous lingula of the mandible is difficult to place. Although possibly an incidental observation, it should be remarked that this process is the site of attachment of the spheno-mandibular ligament, running from the angular spine of the greater wing of the sphenoid. It may be a related and secondary phenomenon resulting from some disturbance of skeletal mechanics.

IV. Conclusion

The anthropometric and medical data presented in this paper are intended to place on record a thorough description of a scaphocephalic cranium. Details, which are sadly lacking in most of the literature upon the subject have been presented at some length, and attention has been drawn to several features not previously noted in the literature dealing with this type of cranial disorder. Notable in this respect are the deeply channeled cranial sinuses, the peculiar form of the mastoids, and the two curious bosses near obelion, which may represent displaced ossification centers. Theories as to the cause of the defect are summarized and discussed. No other pathology is suggested, and there is no evidence to indicate, in this particular specimen, that the scaphoid condition was responsible for any marked physical disorganization or failure of the bodily processes. The skull is a beautifully symmetrical specimen of its kind, perfectly preserved, and worthy of archeological and medical attention.

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Kansas Botanical Notes; 1943[1]

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The year as a whole had about average temperature and somewhat above normal precipitation. Such conditions do not favor the development of the oddities and abnormalities so often reported in these notes. In addition, the typical botanical activities had to give place to activities concerned with the war effort. The herbarium was maintained normally but with very few additions during the course of the year. The most important additions were a group of plants from Gove County by Clement Weber and from Cloud County from S. V. Fraser.

Letters regarding weeds were most numerous in connection with the early spring weeds, *Lamium amplexicaule* and *Stellaria media,* both now rather well distributed through the eastern part of the state and taking their toll in lawns which were improperly cared for or too shaded.

One of the most interesting situations of recent years developed in connection with the stem rust of wheat. With the abnormally wet weather in May and June, together with wet warm nights, it was expected that stem rust would assume epidemic proportions. However, an unusually large air mass with persistently high pressure spread over the Central Plains states as far south as Oklahoma and blocked almost completely the high winds which would have blown rust spores up from the south, where they were plentiful, until much too late to do any serious damage. Here at Manhattan the plates that were exposed by C. O. Johnston, pathologist in the United States Department of Agriculture, collected few or no wheat rust spores, whereas at this time of year many thousand per square foot per day would have been expected.

Twisted maples. About 1915 a row of soft maples, *Acer saccharinum,* was planted along a part of the east side of 16th Street in Manhattan. Apparently three trees were left over. These were twisted around each other and planted in one hole. Each of the three trees thrived and for many years the three together made approximately the equal of any one of the other maples in the row. During

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the great drouth of the 1930's, however, it became evident that one of the three trees was definitely in better shape than the other two. From that time on, the best one took more and more of the space occupied by the group and the two others gradually dwindled. One of the two died during 1941, but the partly rotten trunk and some of the branches were present to the end. The second was almost dead in 1943, at which time it had but a few leafy branches within the crown of the third. All three were cut down on February 19, 1944. At that time the thickness of the twined group was approximately 29 cm., while the diameter at the same level of other maples in the row was 45 cm. At the time of planting, the basal area of each sapling was 1/3 of that of the clump as a whole, but at the time of cutting, the individual trees occupied 13.5, 14.5 and 72% of the total basal area. In other words, the three twisted trees were not an advantage to each other but distinctly a hindrance.

Notes on Basalt Artifacts Found in the Pleistocene Gravels of Kansas

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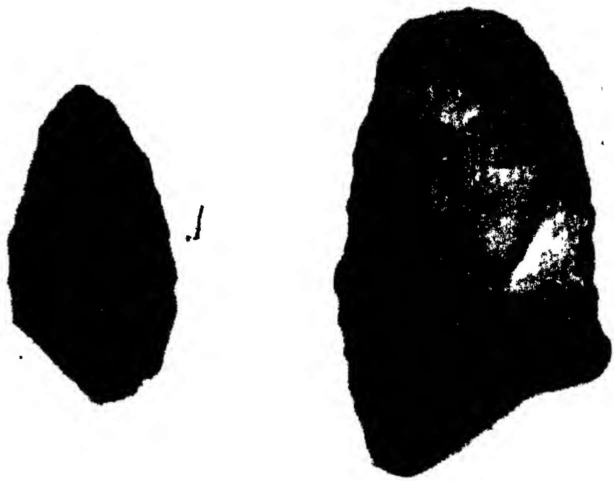
In November, 1943, I accompanied Keith Walker, of Garden City, to a local gravel pit to search for gem materials which had been rumored to occur there. In searching for gems, Walker found a basalt artifact (Pl. 1, Fig. 2) in the gravel about two feet below its contact with the soil zone. A diligent search for additional artifacts or for fossils with which to date the gravels proved futile. The gem content of the gravel, however, correlated perfectly with that of the Smith pit in south Garden City, where several teeth of mammoth, horse and bison of Pleistocene age had been found, and in which Walker later found two worked pieces of basalt. On the basis of the gem material I am of the opinion that the gravels in the two pits are contemporaneous and are Pleistocene in age.

The first artifact found is of the scraper type, although one edge is fairly thin and could have been used also for a knife. It is fairly well worked (Pl. 1, Fig. 2). The artifacts found in the



Smith pit may have been used for scrapers and, although not well shaped, show unmistakable work by man.

Basalt tools similar to those described have been found in certain localities in Logan and Gove Counties on outcrops of Pleistocene gravel. The basalt and artifacts appear to be restricted to such outcrops. In the fall of 1943, Walker and I collected the upper teeth of a mammoth from such an outcrop in Gove County, thus establishing the age of the gravel as Pleistocene. A well-worked tool of basalt was recently brought to my attention by the Reverend Raymond Knowles, of Garden City, who found it in a gravel pit at Bison, in Ellis County. Basalt artifacts, mainly crude arrowpoints (Pl. 1, Fig. 1), occur on or near old Indian camps in the vicinity of Garden City and Hugoton. In the latter region they are also found in sand blowouts associated with Yuma and Folsom points.

In conclusion, the gravels in Finney County in which the basalt tools were found have been correlated on the basis of gem content with nearby gravels of known Pleistocene age, hence the basalt tools are believed to be Pleistocene in age. A careful survey of both sites suggests that the artifacts were deposited contemporaneously with the gravel by a Pleistocene stream. Whether the culture represented by the basalt artifacts preceded the Folsom culture is at present not known. The age of the basalt arrowpoints found in blowouts in Finney, Stevens, Morton and other counties is problematical. Some of the basalt artifacts could be, and probably are, older than the more modern and well-worked flint, jasper, and chalcedony points that were found so abundantly in this region during the dust storms of 1935 to 1939, and which are still being found. It is reasonable to assume that the more modern Indians used artifacts of earlier cultures whenever such materials were available; hence the finding of scrapers, knives and crude arrowpoints of earlier cultures on their camp sites complicates the problem of dating such archeological finds.

New State Records of Mollusca From Kansas

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ABSTRACT: New state records of Mollusca from Kansas including the following species and subspecies of gastropods are reported and their ecology discussed: *Goniobasis potosiensis plebeius* (Anthony), *Pleurocera acuta* Rafinesque, *Pomatiopsis lapidaria* Say; *Gastrocopta corticaria* (Say), *Haplotrema concavum* (Say), *Mesodon inflectus* (Say), *Mesomphix cupreus ozarkensis* (Pilsbry and Ferris), *Stenotrema stenotrema* (Pfeiffer), *Polygyra dorfeuilliana sampsoni* Wetherby, *Polygyra jacksoni* (Bland), *Triodopsis multilineata algonquinensis* Nason, and *Vitridens ligerus* (Say).

INTRODUCTION

During a few days, September 15-24, 1943, of a brief vacation between the summer and the fall semesters at the University of Kansas, Doctor and Mrs. A. Byron Leonard and the author made a tour of the eastern two tiers of counties in Kansas, collecting recent freshwater and terrestrial mollusks.

The first five days were spent north and east of Lawrence including the counties of Jefferson, Atchison, Brown, and Doniphan. The most interesting collecting stations were found near Valley Falls, Muscotah, Iowa Point, White Cloud and Wathena. The remaining time was spent in the counties south and east of Lawrence in Franklin, Miami, Linn, Bourbon, Crawford, Cherokee and Labette Counties. Pigeon Lake and Murray Lake in Miami County, a locality in the Ozark region 6 miles east of Baxter Springs in Cherokee County, and the course of the Neosho River which was followed upstream from Chetopa to Iola offered the best collecting stations. The total distance covered was 700 miles.

The region north and east of Lawrence differs in several respects from that of the south and east area. Northeastern Kansas lies in the glaciated area of Kansas and is characterized by gently rolling hills of which some are several hundred feet in elevation. These are the result of the deposition of glacial till or outwash and glacial ice, and stream or recent stream erosion. This area is now drained by streams generally flowing eastward into the Kansas or

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the Missouri Rivers. Timber, consisting chiefly of oak, hickory and elm, is largely restricted to water courses or the slopes of hills.

The area south and east of Lawrence is a flat plain intersected chiefly by the Marais des Cygnes, a tributary of the Missouri River; the Neosho River which flows into the Arkansas river; and Spring River which drains into the Neosho River. Since the timber is found only along the streams, or near lakes such as Pigeon Lake or Murray Lake, large areas of treeless plain in this part of the state afforded very little collecting. The extreme southeastern area lying in the Ozark region is characterized by low, rocky hills timbered with oak and hickory. Ledges, rubble, leaf mold and fallen timber provide habitats for terrestrial snails. This is one of the few places in Kansas where small streams are clear and non-silted. Because these hills are separated geographically from other hills in Kansas, interesting ecological and faunal distributions can be observed here.

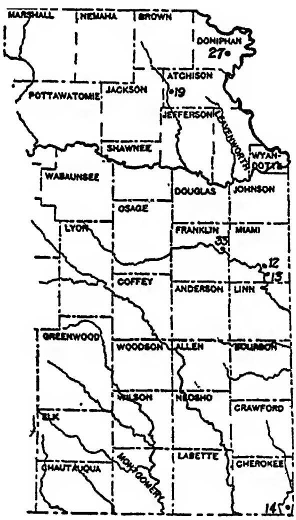

FIG. 1.—Localities From Which New State Records Were Obtained.

This collecting trip was made possible by a Grant-in-Aid from the Kansas Academy of Science Research Fund, for which the author wishes to express her appreciation. Acknowledgments of appreciation are extended to Doctor A. Byron Leonard for the direction of the author's research study; to Mr. Calvin Goodrich, Museum of Zoölogy, University of Michigan, Ann Arbor, for the identification of certain specimens; to Doctor Claude W. Hibbard, Curator of Vertebrate Paleontology and Doctor H. H. Lane, Director, Dyche

Museum of Natural History, University of Kansas, for the use of various facilities.

The following discussion concerns 12 species or subspecies of freshwater and terrestrial gastropods included in this collection, which are new to the recorded gastropod fauna of the state of Kansas. All of these specimens are catalogued in the mollusk collection of the Museum of Natural History, University of Kansas, Lawrence.

Discussion of the New Records

Order Ctenobranchiata

Goniobasis potosiensis plebeius (Anthony)

Plate I, Fig. 4; Cat. No. 1313

The light amber-colored, finely striate, glossy shell, is sharply conic above the periphery on the body whorl and subovate below. The scarcely inflated, slightly shouldered whorls increase regularly in size from the apex to the carina on the periphery of the ultimate whorl. The carina is frequently paralleled by secondary ridges above and below. The height of the ovate, simple-lipped aperture is slightly greater than the height of the spire. The opening of the aperture is closed with a thin, glossy operculum when the animal is withdrawn. The shell tends to become heavily encrusted with algae from the stream.

Goniobasis potosiensis plebeius was discovered, in the spring of 1943, by Hibbard, living in large numbers in a small, clear stream which was flowing below timbered hills in the Ozark region, 6 miles east of Baxter Springs, Kan., locality 14. This stream, a small tributary of Shoal Creek, has a bed of gravel or shingle, without the silt so characteristic of most Kansas streams. Later in the autumn of the year, our field party found that severe floods had washed the snails toward Shoal Creek. They were found near the mouth of the small stream but in small numbers. They had at that time not worked their way back up stream to their former habitat. The species, *G. potosiensis* (Lea) "occupies a fairly restricted area of the Ozark region of Missouri". (Goodrich, 1938, p. 8).

Height	Diameter	No. of Whorls
16.3 mm.	8.3 mm.	8
16.1	8.3	8½
16.1	8.2	8

Pleurocera acuta Rafinesque

Plate I, Fig. 10; Cat. No. 1322

The imperforate, operculate shell, composed of ten, non-inflated

whorls increasing regularly in size, is sharply conic from apex to the periphery on the body whorl. A carina parallels the suture above from the 2nd apical whorl to the penultimate whorl. On the ultimate whorl the carina parallels the periphery slightly above. The outer lip of the oval aperture is simple, the inner lip reflected and continued over the body whorl as a thin callus. The outer lip is frequently worn and sharply broken back. Wide, purple to dark brown bands alternate with light yellow or white bands along the suture. The somewhat heavy, glossy shell is smooth except for numerous, sinuous, vertical striations which extend from the suture to the base of the body whorl.

A single dead shell washed ashore was found on the banks of the Marais des Cygnes river just below the river bridge at LaCygne. In the fall of 1941, Leonard found a few dead shells farther upstream, near Rantoul, locality 33. *Pleurocera acuta* is generally known from the Great Lakes region. Baker (Baker, 1928, p. 173) suggests that the river race, as known from western New York to the Great Lakes region, Canada south to the Ohio river drainage, be known as *P. a. tracta* (Anthony). However, our specimens were referred by Calvin Goodrich, (Goodrich, 1941), Museum of Zoology, University of Michigan, to *Pleurocera acuta.*

Height	Diameter	No. of Whorls
17.0 mm.	6.9 mm.	7

Pomatiopsis lapidaria Say
Plate I, Fig. 9; Cat. No. 1321

The amber to dark brown, glossy, perforate, operculate, subconic shell consists of strongly inflated whorls regularly increasing in size toward the body whorl and separated by a sharply and deeply incised suture. The outer lip of the oval aperture is simple while the inner is somewhat reflected and continuous over the body whorl. The surface is marked with fine, microscopic vertical striations and is sometimes granular.

One and one-half miles south of Muscotah, locality 19, in a 40-acre marshy area isolated within a pasture, *Pomatiopsis lapidaria* was living either on the moist ground or low on the stems and leaves of sedges, reeds and cattails. Although *P. lapidaria* is a nocturnal snail, (Ameel, 1938, p. 703), we found it active during the day at this place probably because of the dense shade afforded by the vegetation. Associated with this species were *Succinea haydeni* Binney, *Triodopsis multilineata algonquinensis* Nason, and *Stenotrema monodon aliciae* (Pilsbry). *P. lapidaria* was considered by Baker (Bak-

er, 1928, p. 166) to be amphibious in habit, while Pilsbry (Pilsbry, 1896, pp. 37-38) believes the various species of *Pomatiopsis* should be regarded to be as much of a terrestrial form as are the *Succinea*. However, *P. lapidaria* has not been found along the banks of the streams of Kansas possibly because of the destruction of the various flora by the spring floods. Although this is the only known recent occurrence of this snail in Kansas, it was found at this locality in considerable numbers. Leonard (Frye, Leonard, and Hibbard, 1943, p. 40), reported this species in a Pleistocene deposit of Russell County, Kansas. The general distribution includes the states of New York to Iowa, Michigan, Wisconsin, south to Missouri, Alabama, and Georgia. (Baker, 1928, p. 166).

Height	Diameter	No. of Whorls
6.7 mm.	3.5 mm.	7
6.6	3.5	7
6.2	3.3	6½

Order Pulmonata

Gastrocopta corticaria (Say)

Plate I, Fig. 1; Cat. No. 1317

Because this shell is very small, it may be easily overlooked. It is subconic in shape, perforate, and composed of 5½ somewhat inflated whorls which gradually increase in size from the flattened apex to the body whorl. The suture is narrow and sharply incised. The shell, white to gray in color, not glossy, is marked with fine, vertical striations and small granulations. The peristome of the oval aperture is white, the margin is simple, and expanded; the terminations are reflected, approaching, but not continuous. An outstanding characteristic of this *Gastrocopta* is the small number and small size of its denticles which include only an angular and a parietal, either fused or in two small nodules one below the other; and a low, nodular columellar lamella.

So far as known, *Gastrocopta corticaria* is not widely distributed in Kansas. A small series of this woodland form was found in drift washed down from the slope in the Ozark region, southeast of Baxter Springs, locality 14. Its previously reported general distribution includes Maine to Ontario, south to Georgia, northern Alabama and Louisiana, west to Minnesota, Iowa and Arkansas (Tryon and Pilsbry, 1916-1918, pp. 52-53).

Height	Diameter	No. of Whorls
2.5 mm.	1.1 mm.	5½
2.4	1.1	5½

Haplotrema concavum (Say)
Plate I, Figures 2, 5; Cat. Nos. 1324, 1325

Haplotrema concavum has a yellow to pale green, glossy heavy, dextral shell, with a scarcely elevated spire. The five whorls, rounded but flattened above, increase regularly in size and terminate with an oval aperture, slightly turned downward. The peristome is simple, scarcely reflected at the base; the terminations are approaching and connected across the rounded periphery with a thin callus. Fine vertical striations cover all the surface but that of the nuclear whorl. All of the volutions are seen through the wide, conic umbilicus. The animal, protected by a stout shell, has been known to feed upon other snails, even attacking *Polygyra.* (Goodrich, 1932, p. 26).

Early in the spring of 1943, Leonard found a small series of this snail living with *Triodopsis* under rocks on the slopes of Murray Lake, locality 12, and Pigeon Lake, locality 13. Later in the autumn the members of our field party found only dead shells, which was propably due to dry weather conditions. In Kansas this species is

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PLATE I.

FIG. 1. *Gastrocopta corticaria* (Say)
x 10

FIG. 2. *Haplotrema concavum* (Say)
x 2

FIG. 3. *Vitridens ligerus* (Say)
x 2

FIG. 4. *Goniobasis potosiensis plebeius* (Anthony)
x 2

FIG. 5. *Haplotrema concavum* (Say)
Umbilical view
x 2

FIG. 6. *Mesomphix cupreus ozarkensis* (Pilsbry and Ferris)
x 2

FIG. 7. *Triodopsis multilineata algonquinensis* Nason
x 2

FIG. 8. *Polygyra jacksoni* (Bland)
Umbilical view
x 5

FIG. 9. *Pomatiopsis lapidaria* Say
x 5

FIG. 10. *Pleurocera acuta* Rafinesque
x 2

FIG. 11. *Polygyra dorfeuilliana sampsoni* Wetherby
Umbilical view
x 5

FIG. 12. *Stenotrema stenotrema* (Pfeiffer)
Umbilical view
x 4

FIG. 13. *Mesodon inflectus* (Say)
Umbilical view
x 4

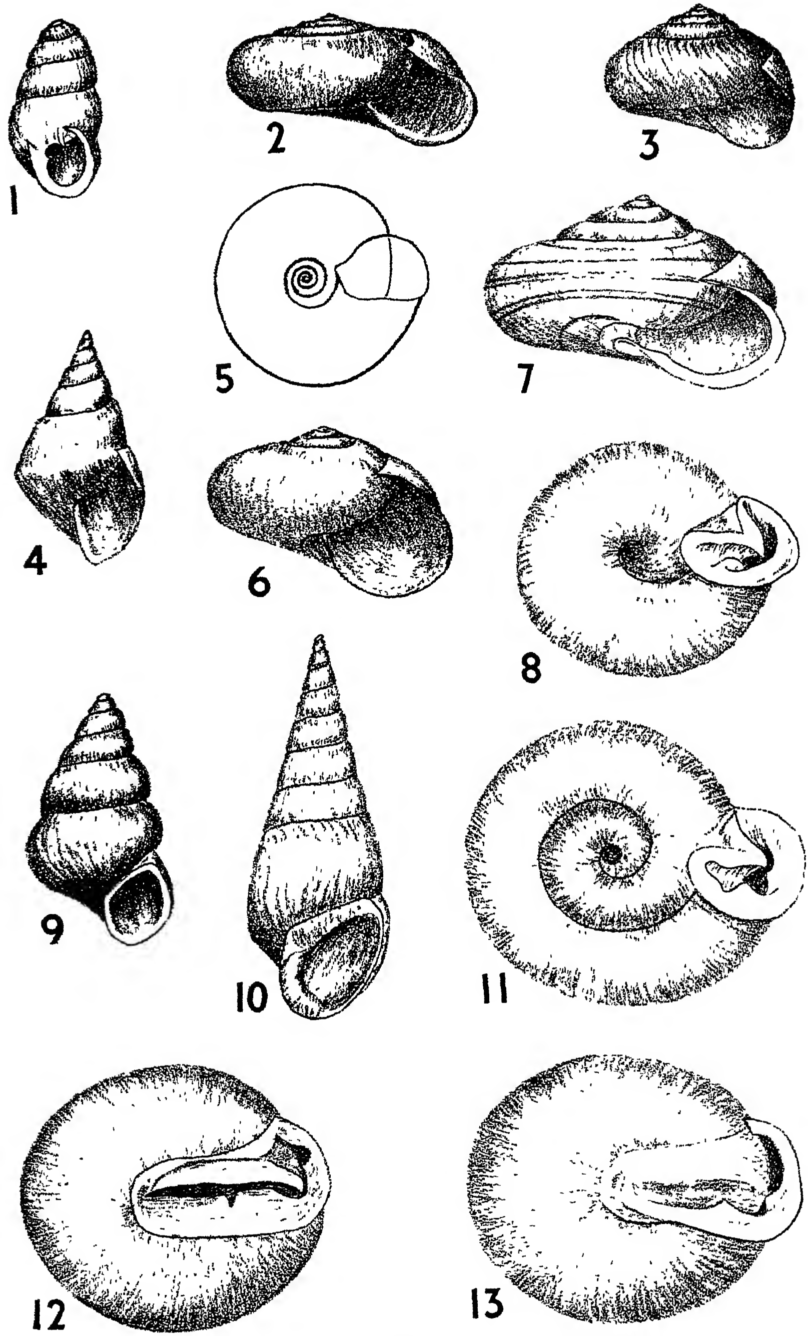

Plate I.

now known only from the eastern part of the state. It has been reported from the areas of Maine to Minnesota, and Iowa; Canada to Georgia and Mississippi, (Baker, 1902, pp. 172-173); Michigan, (Goodrich, 1932, p. 26); Missouri, Arkansas, (Pilsbry and Ferris, 1906, p. 557).

Greater Diameter	Height	Number of Whorls
14.9 mm.	6.7 mm.	4½
14.3	6.7	4½
13.3	6.5	4½

Mesodon inflectus (Say)

Plate I, Fig. 13; Cat. Nos. 1326, 1327

The dextral, discoidal shell, with slightly elevated spire, is composed of 5 rather tightly coiled whorls, which increase gradually in size to the body whorl. The ultimate whorl is flattened above, rounded below the periphery, deflected downward and guttered behind the peristome. Fine, interrupted striations cover the entire surface. Short, curved, pointed periostrical processes cover the upper part of the ultimate whorl and disappear on the base. The peristome is white, and reflected; the lower termination covers the umbilicus. A thin callus across the parietal wall connects the two terminations. Of the two lip teeth, the upper, usually the larger, is either marginal or somewhat recessed; the lower is tubercular in form and marginal. These are separated by a squarish notch, usually wider than high. In specimens from the same locality there is some variation in the relative sizes of the two denticles: in some both denticles are well developed while a few individuals are quite depauperate. The parietal tooth is long, not as high as the margin of the outer lip. Its outer extremity is bent downward and terminates just above the outer lip tooth.

Early in the spring, 1943, Leonard found this species living in large numbers on the rocky, timbered slopes, east of Baxter Springs, locality 14. A small series was also found at that time on the rocky, timbered slopes of the Pigeon Lake region, locality 13. Later, in the autumn, during dry weather conditions, large numbers of dead shells were found. *Mesodon inflectus* is widely distributed: records include the states of Ohio, Michigan, Indiana ,Illinois, Kentucky, Tennessee, North Carolina, South Carolina, Georgia, Florida, Alabama, Mississippi, Louisiana, Arkansas, Oklahoma, and Missouri. (Pilsbry, 1940, pp. 771-773).

Greater Diameter	Height	Number of Whorls
11.1 mm.	6.3 mm.	5
10.3	5.6	4½
9.8	5.5	5

Mesomphix cupreus ozarkensis (Pilsbry and Ferris)

Plate I, Fig. 6; Cat. No. 1328

The shell of *Mesomphix cupreus ozarkensis* is thin, dull olive green to horn brown in color. All the whorls, except the smooth nuclear one, are covered with fine growth lines. The shell is dextral, discoidal, and the spire somewhat elevated. The 4½ rounded whorls increase rapidly in size and terminate in a large, obliquely oval aperture. The terminations of the simple peristome approach and are connected across the periphery by a thin callus. The umbilicus, narrow and deep, is contained about 9 times within the lesser diameter.

Early in the spring of 1943, Leonard found this species in large numbers in association with *Triodopsis albolaboris alleni* ('Wetherby' Sampson), *Mesodon clausus* (Say) and *Mesodon thyroidus* (Say), on the timbered slopes east of Baxter Springs, locality 14. *Mesomphix cupreus ozarkensis* was burrowed in the ground under a layer of leaf mold. However, since the day was cloudy and rainy, a few individuals were above the ground near large rocks. Due to unfavorable dry conditions, later, in the fall only dead shells were recovered. In Kansas, *M. c. ozarkensis* is known only from this locality of the southeastern corner of the state, in the Ozark hills. Pilsbry, (Pilsbry, 1911, pp. 472-473), reports *M. c. ozarkensis* from the Ozark region of Arkansas and Oklahoma.

Greater Diameter	Height	Number of Whorls
16.0 mm.	11.7 mm.	4¼
15.6	12.0	4¼

Polygyra dorfeuilliana sampsoni Wetherby

Plate I, Fig. 11; Cat. Nos. 1318, 1319

This discoidal, scarcely elevated, light horn-colored, glossy shell is composed of 6 tightly coiled whorls which increase regularly in size to the aperture. Except the nuclear whorl, the surface is coarsely striate, with the striations diminishing over the base of the body whorl. The umbilicus reveals only about one volution. The ultimate whorl is constricted just behind the heavy, reflected peri-

stome. Three denticles, two marginal and one perietal, nearly fill the small, oval, downward deflected aperture. The upper marginal tooth is noduler and deeply seated. The basal tooth, tubercular in form, begins at the outer margin of the peristome and extends inward at an angle to the suture of the body whorl. The parietal tooth, narrowly elongate, extends from the lower termination of the peristome, inward where it terminates just above and behind the upper marginal denticle. A continuation of the upper lip termination meets this tooth centrally in the form of an elongated buttress. A low, nodular columellar tooth is recessed inward about one-fourth of a volution.

Polygyra dorfeuilliana sampsoni lives on the rocky, wooded slopes east of Baxter Springs, locality 14, in association with *Polygyra jacksoni* (Bland). At Pigeon Lake, locality 13, a small series was collected from the rocky, timbered slopes. *P. d. sampsoni* occurs also in parts of Missouri, adjacent counties of Arkansas, Oklahoma and as far south as Waco, Texas. (Pilsbry, 1940, pp. 636-637).

Greater Diameter	Height	Number of Whorls
8.7 mm.	4.0 mm.	5½
8.5	3.5	5½
8.1	3.5	5½

Polygyra jacksoni (Bland)
Plate I, Fig. 8; Cat. No. 1316

The glossy, striate, horn-colored, discoidal, dextral, scarcely elevated, narrowly umbilicate shell is composed of 5½ tightly coiled whorls which, separated by a narrow and distinct suture, increase gradually in size toward the aperture. The body whorl is rounded below and flattened above its high periphery, but guttered and then inflated behind the reflected peristome. The nuclear whorl is faintly striate and granular. Striations, faint on the second and third spiral whorls, increase toward the ultimate whorl where they are conspicuous above but faint below the periphery. The aperture, deflected obliquely downward, is rounded lunate in shape. The parietal tooth, continuous with the terminations of the peristome, is bicrural, linguiform, and deflected upward and extended inward. It is sharply pointed where it terminates just below the periphery. The narrow, elongate, basal tooth extends inward and upward from the margin of the aperture. A columellar tooth is lacking.

Polygyra jacksoni (Bland) is known in Kansas from the timbered slopes of the Ozark hills, in association with *Polygyra dorfeuilliana sampsoni*, east of Baxter Springs, locality 14. It has been

reported from the Ozark region including the state of Missouri, Arkansas, and Oklahoma. (Pilsbry, 1940, pp. 631-632).

Greater Diameter	Height	Number of Whorls
7.9 mm.	3.9 mm.	5½
7.5	3.5	5½
6.7	3.5	5½

Stenotrema stenotrema (Pfeiffer)
Plate I, Fig. 12; Cat. Nos. 1314, 1315

The shell of this species is dark buff, low, broadly conic, imperforate and composed of 5½ tightly coiled, somewhat inflated whorls which increase gradually in size to the body whorl. The ultimate whorl is broadly convex and deflected downward, its periphery high. The shell is slightly guttered just behind the upper portion of the peristome. The nuclear whorl is finely wrinkled; the remaining whorls are covered with fine, irregular vertical striations. Rather fine periostrical processes cover the later whorls. The aperture is long and narrow. The upper part of the peristome is inflated but simple. The basal portion is reflected and has a well marked notch located on the center of its inner border. The parietal tooth is narrow, long and curved downward at its outer extremity and where it enters the aperture. It is high but does not extend above the upper margin of the basal lip. A thin callus connects the terminations of the lip.

In Kansas a small series of *Stenotrema stenotrema* was found on a hillside timbered with oak and hickory, one-half mile northwest of Wathena, locality 27. Another small series was found on the timbered Ozarkian hills east of Baxter Springs, locality 14. *S. stenotrema* has been reported from Ohio, Indiana, Illinois, Missouri, Arkansas, Oklahoma, Louisiana, Virginia, West Virginia, North Carolina, Kentucky, Tennessee, South Carolina, Georgia, Alabama, and Mississippi. (Pilsbry, 1940, pp. 655-657).

Greater Diameter	Height	Number of Whorls
10.6 mm.	7.0 mm.	5½
10.3	6.6	5½
10.1	6.5	5½

Triodopsis multilineata algonquinensis Nason
Plate I, Fig. 7; Cat. No. 1312

All of the 5 inflated whorls of the dextral, depressed globose,

glossy shell can be seen from a profile view. The surface except that of the smooth nuclear whorl is covered with coarse, closely-spaced vertical striations which become less distinct over the base. The shell is decorated with reddish brown, spiral bands varying from a series of numerous, narrow, to very wide bands with only a few narrow ones on the base. In some instances the entire shell is a solid reddish-brown. The large, oval, edentate aperture is bordered with a white or pink, reflected lip; the lower termination entirely covers the umbilicus. A very thin callus connects the two approaching, but widely separated, terminations. The basal margin of the aperture is slightly thickened by a low callus. This subspecies, geographically separated from the typical species, differs from the latter in being smaller in size and in the occurrence of the almost or completely solidly banded forms.

Our series of *Triodopsis multilineata algonquinensis* was found living in a marshy area, isolated in a large pasture, 1½ miles south of Muscotah, locality 19. It, in association with *Pomatiopsis lapidaria* (Say), *Succinea haydeni* Binney, crawled on the moist ground or low on the leaves of the dense growth of reeds ,sedges, and cattails. Here lived also *Stenotrema monodon aliciae* (Pilsbry) on the moist ground. The constant flow of an artesian spring keeps this area marshy and soggy the year round. Previously reported occurrences include the state of Illinois, Indiana, Wisconsin, Iowa, and Nebraska. (Pilsbry, 1940, p. 849).

Greater Diameter	Height	Number of Whorls
18.6 mm.	12.3 mm.	5
18.3	11.5	5
17.2	11.0	5

Vitridens ligerus (Say)

Plate I, Fig. 3; Cat. No. 1320

The broadly conic, dextral shell, light amber to greenish yellow in color, shining, is composed of 6½ to 7 whorls, separated by a sharply defined suture. The first three volutions are tightly coiled; the following increase rapidly in size. The apical whorl is smooth. Striations on the remainder of the shell are conspicuous but disappear over the base of the inflated, rounded, body whorl. The lunate, sharp-edged aperture extends from slightly above the periphery to the very small, almost obscure umbilicus. A low, wide, white callus thickens the inner basal portion of the aperture.

The Pigeon Lake area, locality 14, supports one of the few virgin

timber growths in Kansas. Here, in a grove, hickory trees reach a height of about 50 feet. The fallen timber, debris and leaf mold in this area, which is moist and almost marshy, afford a good habitat for this species. Leonard first found a colony of this species under a log with *Pitymys.* A number of the shells had been chewed by these mice. The collection made in the fall of the year also includes a fair series of unworn shells. The general distribution includes the area from Ontario, Canada, to Michigan, south to Oklahoma, Louisiana, Virginia, and Tennessee. (Baker, 1902, p. 192).

Greater Diameter	Height	Number of Whorls
12.6 mm.	9.6 mm.	6½
12.0	8.7	6½
11.5	8.7	6

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Insect Photography With Limited Equipment

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One good illustration may be worth 10,000 words, but one poor photograph of an insect, or of insect damage, frequently is worse than none. Entomological illustrations often fail of their purpose because they are not sharp, clear, and distinct, or because the photographer did not concentrate on the specific characteristics to be emphasized in the illustration. Most insects are too small and some types of injury too inconspicuous to photograph properly with a camera as ordinarily equipped. Special laboratory equipment is expensive and is now generally unobtainable. However, by utilizing a camera with a long bellows extension and such lenses as are generally available around an entomological laboratory, equipment equal in efficiency to the best can be made up at inconsequential cost.

Laboratory Equipment for Insect Photography

A camera stand and home-made cameras for making photomicrographs and extreme close-ups, with attachments for improving insect photographs by enlarging portions of large or small negatives, is illustrated in Plate 1. The apparatus was built by the junior author with a few ordinary tools and a soldering iron.

The 18x21-inch base of the stand consists of a heavy metal band 2½ inches high (a piece of discarded furnace binder) filled with a rich mixture of concrete reinforced with ¼-inch steel rods threaded and bolted to the outside frame. The upright track is a 4-foot length of 1-inch galvanized pipe screwed into a coupling anchored and imbedded in the concrete base. Slides for C, D, E, H, and F are short pieces of 1¼-inch galvanized pipe fitted with set screws for adjustment. Set screws are ⅜x8-inch bolts with heads cut off and bent as shown. They are set in nuts soldered to the slides, with the threads continuing on through the slides.

The camera carrier, D, is made of 1x⅛-inch strap iron bolted to wooden strips to form a support for the camera base as shown. The wooden platform with a tripod key at the center can be moved vertically or swung horizontally and is designed to hold firmly and without vibration any camera from a Leica to a 5x7 view camera.

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The keeper, C, permits the camera to be raised and swung aside without losing register on the specimen. H is a device for micrometer focussing by raising or lowering the platform and camera. It is very useful in photomicrographic work, or when the camera used has no adjustment for fine focussing.

Two cameras are illustrated. The body of camera I is a five-pound syrup can. The bed is of 18-gauge galvanized iron. A ¼-inch nut serves as tripod socket. The back, formed of 22-gauge iron, is grooved on one side to fit a standard small-size film holder. The bottom and opposite side are flanged to fit the film holder closely enough to hold it against the felt facing of the back. The 3¼x4¼ graflex film magazine shown on platform A makes an excellent film holder. The "bellows draw" is obtained by a series of cans soldered to rims of friction lids. These lids make a perfect light-tight seal. Interchangeable combinations ranging from one to four feet can be made up. The combination shown has an effective draw of two feet. The wooden base shown fits over a bolt replacing the tripod screw and helps keep the camera rigid.

Camera J designed for a 20-mm. lens from a 9-mm. movie camera, has an old 5x7 shutter mounted on a salve-box lid. The lid fits various salve boxes soldered to tin or galvanized spouting mounted to fit camera lens boards and various other appliances. A focus-

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Explanation of Plates

Plate I.

Camera Stand and Attachments

A. Base of stand.
B. Upright track.
C. Keeper to hold register when camera is swung aside.
D. Camera carrier.
E. Bracket supporting enlarging projector and negative table.
F. Condenser bracket.
G. Lamp house assembly.
H. Micrometer focussing device.
I. Camera with provision for interchangeable bellows sections.
J. Camera for 20-mm. lens fixed bellows length, showing old shutter adapted for 50-mm. lens. Removal of lens provides microscope sleeve.
K. Ringstand with adjustable glass insect support and background. Partitioned tray is used in photographing living insects.

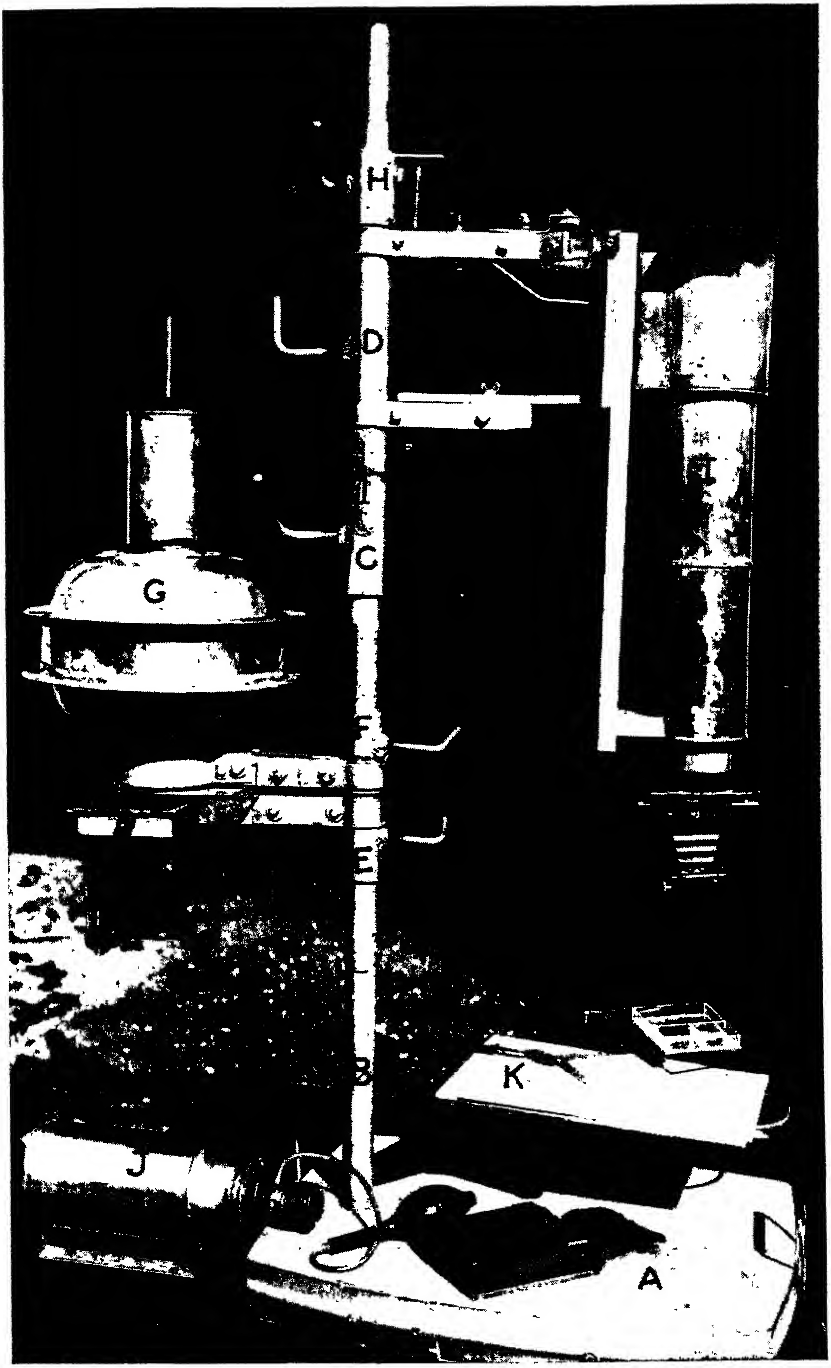

Plate 1.

sing mount for a 50-mm. lens is shown. When the lens is unscrewed, the mount can be used as a microscope sleeve. Mounted on a salve can it may be used as an enlarging projector for high magnifications. All inside parts are painted dead black with lampblack in oil thinned with turpentine. Reflections may be eliminated by use of a loose lining of black crepe paper.

The background and the specimen support are mounted on a ringstand, K, as shown. The 5x7 negative glass, fastened in a piece of copper tubing slotted with a hack saw and bent around two sides of the glass, is an ideal transparent support for the partitioned insect tray which is made up of lantern-slide coverglass and acetate cement.

The enlarging apparatus, E, F, G, is designed particularly for entomological work. It is possible to enlarge from a 1- to a 3-inch square from any part of any size negative up to 11x14 inches. For a 3x4- to a 2x2-inch negative aperture, a camera with a 120-mm. to 72-mm. lens is best. For smaller than 2-inch negatives a lens of 50-mm. focus is desirable. The 4-inch condensing lens (a mounted pair from a stereopticon can serve a dual purpose) and lamp house rest on two sheets of glass holding the negative between them. The short gap between the condenser and the negative insures maximum light efficiency.

The film table, 4x10 inches in size, is a flat sheet-iron plate with a 3x4-inch opening in the center. Bent metal clamps support the camera beneath it. Two short lengths of copper tubing, one telescoping into the other, support the red filter. The light source is enclosed in two 10-inch tin washbasins. The 4-inch hole in the lower basin is fitted with a collar of ½-inch sheet metal which slips over the condenser housing. Over a 2-inch hole in the upper basin a small tin can with four one-half-inch perforations in the sides is soldered, forming a light baffle and support for a tubing-mounted socket containing an ordinary 100-watt frosted bulb. By means of a clamp at the top of the can the lamp can be adjusted up or down for maximum illumination. A second and larger can with a 1-inch vent in the center of the top end is soldered over the first to shut out light and yet allow ventilation. The side of the lamp house is made of strips of bright tin 2½ inches wide cut from large cans and soldered together to form a circular ring or hoop 10½ inches in diameter. Hoops of metal one-half inch wide are soldered around the lips of both basins, and the whole is put together by fitting top and bottom basins to the ring in the manner of closing a salve box.

Good Insect Photographs with Minimum of Film

The central area of the photographic field of a lens, especially with the long-bellows draw and short-focus lenses used in insect photography, yields sharper and clearer negative images than the outer limits of the field. With a 5x7 camera, a film 3½x5 or 2½x3½ inches, centered in the holder, often serves as well as a full-size film. This result is equally true of smaller cameras. During the emergency the photographer has to be satisfied with whatever size of film is available, quite often a box of 5x7 or 8x10. Two 9x12-cm. or four 2½x3½-inch films can be cut from a 5x7 film. An 8x10 film will yield six films 3¼x4 or four 4x5 films. Films can easily be cut, even in total darkness, on a print trimmer, by using brads driven into the board to gauge the size of the film. Satisfactory kits can be made of 5x8-inch index cards cut to fit the film holder, with an opening in the center for the size of film to be used. The side of the card facing the lens is covered with a piece of black film-separation paper with a slightly smaller opening than that in the card, thus forming a recess for the film. The black paper should be mounted on the card with mounting tissue. Strips of film cut 3½ inches wide will fit in ordinary 9x12-cm. holders without kits. Small strips of film may be attached to 5x7 film holders by small bits of scotch tape.

Any photographer knows the prerequisites of a good photograph—good lighting, sharp focus, and correct composition and exposure. In photographing insects, however, the effort required to secure these essentials is less than one-fourth of that necessary in most photography if good pictures are to be made. The major task is to prepare the specimen so that it will look lifelike and exhibit its natural characteristics. The legs and appendages of adult insects, especially beetles, no matter how they are killed, are contracted in an unnatural manner. After more than 25 years of experimentation with many kinds of killing and relaxing agents, the senior writer has not found a perfect method of preparing small beetles for photographing. The most promising method is to kill the insect quickly with heat. A closed Petri dish in an electric corn popper has been found satisfactory for this purpose. Immediately after they are killed, specimens should be rinsed successively in water and alcohol and allowed to dry on a piece of paper toweling. With the beetle held on its back the feet and appendages should be teased out with fingernail or brush and adjusted with a No. 0 camel's-hair brush or fine needle. Vigorous brushing usually relaxes the appendages. The

freshly killed insect can then be placed on a microscope slide or a lantern-slide cover glass and photographed.

Direct sunlight, carbon arc, microscope lamp, or photoflood bulb are all good light sources for illuminating dead specimens. For best results, insects less than one-half inch long require magnification five to eight times with a 48- or 50-mm. objective. Larger insects show sufficient detail if a 72- to 120-mm. objective is used. Bellows extension in both cases should be 10 to 18 inches. In photographing larvae and some light-colored living adults, the best results have been obtained by taking snapshots of the living forms in bright sunlight with a 72- or 120-mm. objective and relatively short draw, or from a reduction of three-fourths to a magnification of three times, according to the size of the insect. Realistic photographs of active adult insects may be obtained by stupefying them with chloroform or chilling them and using a flash bulb for the exposure.

Plate 2 illustrates what can be accomplished in a short time with limited equipment. The stored-grain insects shown were killed,

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Plate II.

Photographs of Insects.

Fig. 1.—Larger black flour beetle.

Fig. 2.—Granary weevil on kernel of wheat containing lesser grain borer in situ.

Fig. 3.—Rice weevil.

Fig. 4.—Lesser grain borer on wheat kernel showing injury.

Fig. 5.—Broad-horned flour beetle♀.

Fig. 6.—Broad-horned flour beetle♂.

Fig. 7.—Saw toothed grain beetle.

Fig. 8.—Flat grain beetle.

Fig. 9.—Lesser grain borer.

Fig. 10.—Showing insects in figures 1 to 9 and adults in Fig. 13 at approximately natural size.

Fig. 11.—Tarnished plant bug and eggs on wheat head, detail enlarged from Fig. 12.

Fig. 12.—Tarnished plant bug and eggs on wheat head.

Fig. 13.—Larvae, pupae, and imago of confused flour beetle.

Insects in Figures 1-8 were photographed on microscope slides held over an illuminated background box on the edges of two strips of glass. The background was printed in after the lights controlling exposure were turned off.

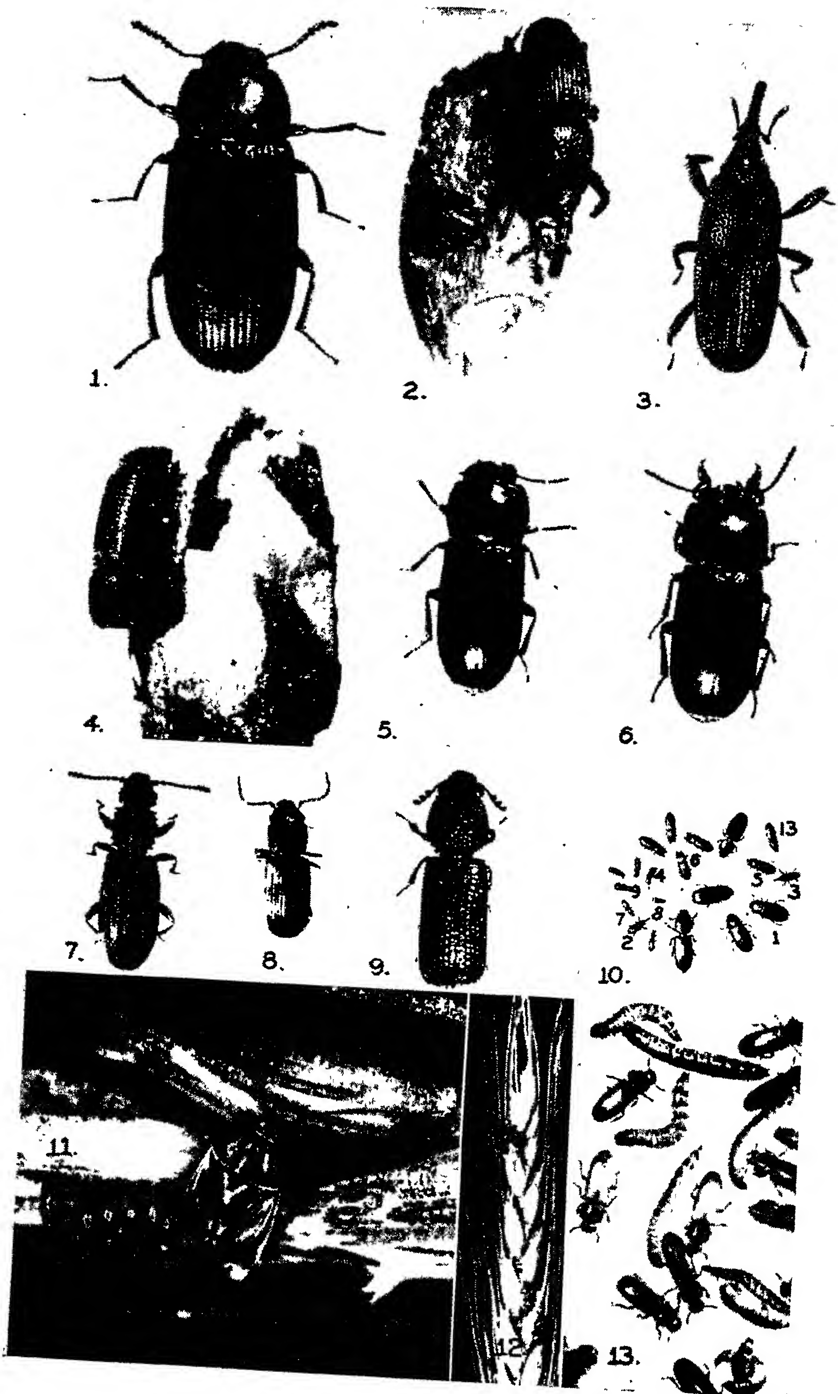

Plate II.

mounted, and photographed in a relatively short time. The pictures could all have been improved by adjusting the appendages more carefully.

Figures 4 and 10 were taken with a Goerz Ango camera fitted with a piece of 3-inch galvanized drain pipe for bellows extension. Arc light was used for illuminatoin. Figures 1, 2, and 9 were photographed with camera shown in Fig. I, Plate i, fitted with a poor quality 50-mm objective, of French make, taken from a 35-mm movie camera. The lens was stopped down to f/32. Figures 3, 5, 6, 7, and 8 were photographed with a 20-mm lens from a 9-mm movie camera using two microscope lamps fitted with photoflood bulbs for illumination. Figure 10 (insects numbered to correspond to those illustrated in figures 1-9 and 13) shows individual insects at approximately natural size. This photograph was taken with the Goerz camera fitted with a Goerz lens of 150-mm. focus at f/25 stop. Figure 13, of living insects, was taken with the same lens and stop but with a 1/150-second exposure in direct sunlight. The negative was enlarged about 2½ times in the enlarger illustrated in Plate 1.

Figures 11 and 12 show possibilities of bringing out details by enlarging only a small fragment of a negative. All work was done with the homemade equipment here described.

No state has a more varied and interesting insect fauna for the photographer to work with than has Kansas. Amateur photographers, entomologists, and others can find an interesting diversion during their spare time in making equipment and developing technique for producing good insect photographs.

Annual Report of the Secretary, April 15, 1944

The minutes of the 75th Anniversary meeting of the Kansas Academy of Science held at Lawrence, 1943, were not published in volume 46 of the *Transactions* but are on file in the office of the Secretary. The account of the meeting published in *Science* was in volume 99:558-559, 1943.

The Secretary compiled a brief history of the Kansas Academy of Science for publication in the A.A.A.S. Bulletin as requested by that organization. It was sent to the A.A.A.S. May 25, 1943.

The Academy made the following A.A.A.S. awards this year:

$40 to Miss Dorothea S. Franzen for "A Study of the Molluscan Fauna and Ecological Relations of the Fauna in the Osage River of Eastern Kansas."

$15 to Dr. L. J. Gier for "A Study of the Effect of Moisture on the Root-Shoot Ratio of Plants."

$13.50 to Mr. Noel Runyon for "A Study of the Chemical Composition of Important Range Plants in Western Kansas."

Dr. Roger C. Smith represented the Kansas Academy at the Third Annual Talent Search Dinner in Washington, D. C., March 7th, 1944, and prepared an excellent report of the meeting which is on file in the office of the Secretary. Dr. Smith also prepared a mimeographed leaflet entitled, "Publications of the Academies of Science of the United States and Canada" which has been mimeographed and distributed by the A.A.A.S. Copies may be secured by addressing the General Secretary, A.A.A.S. Office, Smithsonian Institute Building, Washington 25, D. C.

During the year 3500 letterheads and 3500 envelopes, 100 dues cards and 500 new member cards were ordered from the Kimball Printing Company, Manhattan, at a total cost of $47.50. Later 750 preliminary announcements and 800 programs were ordered from this firm at a total cost of $46.00.

Directions to Sectional Chairmen for preparing the Section programs were mailed early in January.

The dues cards and meeting announcements were sent to the entire mailing list February 10, 1944. The programs were mailed to the entire membership April 5, 1944.

Miss Arleta Boyer assisted most capably in the office of the Secretary.

The Secretary is closing his three years of service in that position. The work of the office has been heavy but has been made pleasant by the cooperation of the other officers and the members of the Academy.

—John C. Frazier, Secretary.

Minutes and Reports of the 76th Annual Meeting Held at Topeka, Kansas, April 15, 1944

The 76th annual meeting of the Kansas Academy of Science was held at Topeka, Kansas, April 15, 1944. The Executive Council consisting of H. A. Zinszer, L. D. Bushnell, J. W. Breukelman, J. C. Frazier, F. W. Albertson, R. H. Wheeler, C. W. Hibbard, A. C. Carpenter, Robert Taft, W. J. Baumgartner, and Miss Edith Beach, met at 8:45 a.m., Saturday, April 15, and transacted the following business:

1. It was agreed to hold our 1945 meeting at Kansas State College, Manhattan, Kansas.
2. It was agreed that accumulated interest on the funds of the Academy, other than that from the Reagan fund, be placed in our general fund for the 1945 Academy year.
3. It was agreed that the Editor, Managing Editor, and Treasurer serve as a committee, with power to act, to decide if there is need to increase the price of reprints to meet their cost to the Academy.

At the general business meeting at 10:00 a.m. on Saturday, April 15, the Academy transacted the following business:

1. Due to insufficient time the Academy dispensed with the reading of the minutes of the last business session held at Lawrence, Kansas, Saturday, April 10, 1943. It was pointed out that these minutes are on file in the office of the Secretary if members are interested in securing them.
2. It was voted, upon recommendation by the council, to hold the 1945 meeting at Kansas State College, Manhattan, Kansas.
3. It was voted, upon recommendation of the council, that the treasurer transfer accumulated interest on the Academy funds, other than interest on the Reagan fund, to our general fund for the 1944-45 Academy year.
4. The report of the treasurer was presented and accepted.

5. The report of the secretary was presented and accepted.

At the general business meeting at 4:00 p.m. on Saturday, April 15, 1944, the Academy transacted the following business:

By agreement the society considered that the business transacted this hour was on a different day from the 8:45 o'clock council meeting, and the 10:00 o'clock business meeting held this same calendar day, so that business presented at either of those sessions could be voted on by the membership at this session. This innovation was necessitated by the one day meeting.

1. Because of the dearth of suitable applications for research funds, it was voted that the chairman of the committee on Research Awards be instructed to receive requests to October 15, 1944, if necessary, to utilize properly the grant of $64.50 allotted to the Academy for 1944 by the American Association for the Advancement of Science.

2. The report of the committee on Necrology was presented and accepted.

3. The report of the committee on Educational Trends and Science Teaching was presented and accepted. The chairman requested the residue of the 1944 grant of $100 be kept available for the use of this committee and asked for additional funds to support this project.

4. The Junior Academy committee reported very little activity during the year because of war conditions, sought a clarification of the Academy's relation to high school science clubs, not members of our Junior Academy, that are members of Science Clubs of America, and requested that the Academy allot $100 for the work of this committee during the next year.

5. It was voted that the names of persons now in the armed services be kept on record for the 1945 Academy year regardless of default of dues.

6. The committee on State Aid reported that we are now receiving $600 annually from the state of Kansas.

7. The report of the committee on Resolutions was read and accepted. The committee report included:

A. In view of the restricted conditions under which all scientists and science teachers now work, we extend our sincere thanks to officers of the Kansas Academy of Science of the past year for their splendid work in carrying on in these difficult times.

B. We extend to Washburn University appreciation for the use of their splendid buildings and facilities for this meeting. And to the local committee of arrangements and to Dr. Philip S. Riggs, chairman, sincere thanks for carefully arranging all details necessary for this meeting.

C. That the Academy express its sincere appreciation to Dr. John C. Frazier, our retiring secretary, for his splendid work of the past three years.

D. The committee instructs the incoming secretary to incorporate in the minutes such other resolutions as he deems fitting and necessary.

8. The report of the auditing committee was read and accepted.

9. The nominating committee reported as follows: President, Dr. Leland D. Bushnell; President-elect, Dr. John W. Breukelman; Vice-President, Dr. Claude W. Hibbard; Secretary, Dr. Donald J. Ameel; Treasurer, Dr. F. W. Albertson; Executive Council, Dr. Harvey A. Zinszer, Miss Edith Beach, Dr. Paul G. Murphy, and Dr. Philip S. Riggs; Editor, Dr. Robert Taft (3 years); Associate Editor, Dr. Stuart Pady (3 years); Academy Representative, Dr. John C. Frazier (3 years); Librarian, Dr. M. J. Harbaugh.

The Executive Council for 1945 convened at 4:30 p.m. with President Bushnell in the chair, at which time the following business was transacted:

1. It was voted to place the residue of the 1944 allotment of $100 at the disposal of the committee on Educational Trends in Science Teaching for the remainder of this fiscal year. Fifty dollars was made available for 1945 with the understanding that the Executive Committee could increase the amount at its discretion if the need arose.

2. It was voted to allot $100 for the work of the Junior Academy in 1945 if need arose for this expenditure.

3. The executive committee was empowered to allot funds in case other committees became active during the year and should require them.

4. The receipt of a letter from Mrs. Reagan was acknowledged.

5. The council approved the suggestion of Dr. Albertson that the money received from bonds maturing in 1945 should be used to purchase government bonds that pay interest each six months

period. This interest would be used in supporting our awards program.

6. It was agreed that the secretary should be reimbursed for expenses incurred while attending the annual meeting.

7. A suggestion that the members of the council other than the secretary should be reimbursed for travelling expenses to and from the place of the annual meeting was not approved.

8. It was agreed that high school science clubs that are members of Science Clubs of America may become members of the Junior Academy of Science without payment of fees.

—JOHN C. FRAZIER and DONALD J. AMEEL, Secretaries.

Kansas Academy of Science—Annual Report of the Treasurer

April 7, 1943 to April 10, 1944

Receipts

Balance in checking account, April 7, 1943		$ 149.37
Annual dues from members		435.25
Ten life membership fees		71.00
Sale of *Transactions*		4.70
Sale of "Twig" Handbooks		19.09
Reprints—1941, $16.68; 1942, $27.35; 1943, $212.18		256.21
Exchange Rights		
University of Kansas, Vol. 46	$200.00	
K. S. C. Vol. 46	200.00	
Fort Hays Vol. 46	100.00	500.00
State of Kansas		600.00
A.A.A.S. Award		68.50
Reagan Bond (called in by U. S. Treasury)		1,000.00
Interest on Endowment Fund		101.07
		$3,205.19

Disbursements

Awards:		
Dorothea Franzen (A.A.A S)	$ 40.00	
L. G. Gier (A A.A.S.)	8.62	
Noel Runyon (A.A A.S.)	13.50	$ 62.12
President and Executive Council		29.95
Secretary—programs, help, express charges, stamps, telephone calls, etc.		298.17
Treasurer—bond, lock box, help, Reagan Bond ($1,000.00)		1,032.65
Editorial Board		
Managing Editor—mailing *Transactions* ($15.02), visiting legislature ($18.96), and cuts (vol. 46, $120.61)		154.59
Editor		
Printing "Science and War"	$ 85.00	
Mailing "Science and War"	25.64	
Printing Vol. 46, *Transactions*	939.00	
Printing Reprints	303.10	1,352.74
Sectional Chairmen		
Zoology Section	0.90	
Chemistry Section	4.08	
War Work Survey	5.00	9.98
Balance in checking account, April 10, 1944		264.99
		$3,205.19

SUPPLEMENTARY STATEMENT

Accounts receivable (Reprints)	$ 39.90
Accounts payable (Award to L. G. Gier)	6.38

—F. W. ALBERTSON, Treasurer.

Transactions
Kansas Academy of Science

Volume 47, No. 3 | March, 1945

The Development of Kansas Wildlife Conservation Policies

EDWIN O. STENE
Bureau of Governmental Research, University of Kansas, Lawrence.

Conservation of the state's natural resources has long been a cause which the Kansas Academy of Science has whole-heartedly sponsored and Academy members have taken an active part in many of the conservation activities developed in the state since the Academy was first organized in 1868. It is with particular satisfaction then that we present Dr. Stene's study of wildlife conservation in Kansas. It is a chapter of the state's history which should be read by every intelligent citizen of Kansas interested in outdoor life. We hope eventually to follow this article with further studies dealing in detail with the efforts at fish and game propagation and with the development of the state's recreational areas.—The Editor.

Prior to the arrival of white settlers, the territory of Kansas was blessed with an abundance of wild game birds and animals. The buffalo, by reason of his size, which contributed to the impressiveness of his great numbers, overshadowed all other forms of wild life in this area; but the accounts of exploration and travel also tell of multitudes of antelope, deer, elk, wild turkey and most of the smaller birds and animals that now inhabit this state.

Lewis and Clark did not enter Kansas except along the northeastern boundary. However, their journals contain several references to the presence of wild game along the Missouri River between Kansas City and the parallel of 40° latitude. In this part of the journey members of the expedition saw buffalo for the first time,[1]

and here they saw "deer and turkeys in great quantities on the bank".[2] Mention was made also of "great quantities of fish and geese" in a lake near the Missouri River.[3] On the day after the party left the mouth of the Kansas River, Sergeant Patrick Gass noted that on the south side of the Missouri "there were the most signs of game I ever saw".[4]

Two years later, Pike journeyed across the state from east to west. The number and the variety of game that he encountered is suggested by his report that on September 12, 1806, "I stood on a hill, and in one view below me saw buffalo, elk, deer, cabrie [antelope], and panthers".[5] Pike passed through the heart of the buffalo pastures, and on November 6 of the same year, in the neighborhood of present day Garden City, he wrote that "I will not attempt to describe the droves of animals we now saw on our route; suffice it to say that the face of the prairie was covered with them, on each side of the river; their numbers exceeded imagination".[6]

For a half century between the time of the Lewis and Clark expedition and the coming of the permanent settlers, hundreds of hunters, trappers, fur traders, and other travelers roamed the prairies. Even the earliest settlers, like the Indians, took to hunting and trapping, and in many instances these activities constituted their principal occupation, with farming a somewhat half-hearted side line. The following description by Everett Dick is indicative of the vast sources of supply for hunters and trappers during the third quarter of the 19th century:[7]

> Turkeys were plentiful among the timber along the streams; the prairies were alive with prairie chickens; antelope, deer, elk, and buffalo roamed a short distance inland; wild ducks and geese were plentiful along the streams and lakes. Even bears were to be found in the woods along the larger rivers. Most of these animals melted before civilization like snow before a chinook wind, but prairie chickens, strange to say, actually increased following the occupation of the country by the homesteader. An abundance of waste grain made it possible for the country to support more birds than formerly.

The Plight of the Buffalo

As already mentioned, stories of the immense herds of wild buffalo, or American bison, found prominent places in the writings of practically every traveler of literary inclination who passed through Kansas during the years that immediately preceded and followed the Civil War. Horace Greeley, writing of a journey through Kansas Territory in 1859, spoke of having seen "the whole region from a mile to three miles south of our road, and for an extent of at least three or four miles east, fairly alive with buffalo.

There certainly were not less than ten thousand of them; I believe there were many more".[8] On the following day Greeley wrote again that "I know a million is a great many, but I am confident we saw that number yesterday".[9]

The hunting of buffalo became increasingly common in the decade of the 1860's, and the buffalo range was gradually being pushed westward by the settlers, and split into two large areas by the transcontinental railroad. It was not until the early years of the 1870's, however, that the slaughter of buffalo became a large scale commercial enterprise which rapidly brought the animal to extinction as a form of wild life. As late as 1872 one writer made the observation that "these wild cattle . . , if called upon could supply the whole Yankee nation with meat for an indefinite period".[10] But already the great slaughter was in progress. The buffalo was not called upon to supply the Yankee nation with meat. He was killed for his hide alone, or for his hide and tongue, and much of the time his carcass was left for the coyotes, the crows and the maggots. Estimates have been made that during the three years of 1872, 1873, and 1874, a total of four and a half million buffalo were destroyed in the middle west, probably three quarters of them for the mere sake of their hides.*

A few half-hearted attempts were made to enact legislation for the protection of the buffalo. In the last days of the session of 1872, the legislature of Kansas passed an act to "prevent the wanton destruction of buffalo." But the measure, House Bill No. 106,[11] apparently met with an executive pocket veto; it never appeared in the statute books. In the same year the national House of Representatives agreed to a resolution directing the committee on territories to inquire into the expediency of enacting a law for the protection of buffalo, elk, antelope and other animals that ran wild in the territories of the United States, and a bill was introduced to restrict the killing of buffalo on the public lands. Two years later Congress passed an act to "prevent the useless slaughter of buffalo within the United States territories;" but, like the Kansas bill, this measure did not appear in the statute books; it, too, evidently met with a

*William Blackmore wrote in the introduction to Richard Irving Dodge's *Plains of the Great West* (1877), that "when in the west in 1872, I satisfied myself by personal inquiries that the number of buffalos then being annually slaughtered for their hides was at best one million per annum." p. xiv.

E. Douglas Branch speaks of the large buffalo skin tanneries in western Kansas and in Colorado. The largest of these was in Greeley, Colorado. At another, in Dodge City, Kansas, a newspaper told how it was not uncommon to find from 60,000 to 80,000 buffalo robes and hides in their warehouse and yard. *The Hunting of the Buffalo,* 1929, pp. 154-155.

pocket veto. Reason for this veto is suggested by the fact that the secretary of interior had questioned the wisdom of protecting the buffalo, on the ground that the Indians could never be civilized until the buffalo had been exterminated.[12] Even if this bill had passed, however, it would not have protected the buffalo in Kansas; it applied only to the territories.

No further action was taken either by Congress or by the Kansas legislature for the protection of buffalo. Moreover, the time for protective legislation had passed. In 1877 Col. Dodge wrote that "the buffalo is virtually exterminated. No legislation, however stringent or active, could now do anything either for or against the trade of the 'buffalo products'."[13]

It cannot be said that protective legislation would have prevented the destruction of the buffalo. With the coming of the enclosure movement and the disappearance of vast areas of open prairie, these large grazing animals were probably doomed to extinction. Yet, the immediate reason for opposition to any protective legislation in the early seventies was the profitable business of selling and shipping buffalo hides. In Dodge City, Wichita, and other points in Kansas, large trading centers arose, and from these centers spread the concentrated attack on the buffalo herds. The buffalo was too profitable to permit legislation which would interfere with the traffic. A few states established closed season on the killing of buffalo,* but none of them were in the areas of the immense herds to the south of the first transcontinental railroad. Regardless of the possible effects of other courses of action, the fact remains that the buffalo in Kansas was never so much as blessed with the positive declaration of policy found in protective legislation.

Destruction of Other Large Game

It was said by some writers of the nineteenth century that the killing of buffalo was not a sport in the same sense as the killing of deer and other forms of wild game. The buffalo had neither the cunning nor the protection of natural surroundings ordinarily associated with the objects of sportsmanship.[14] For that reason the sportsmen may have been more interested in the protection of the deer, elk, antelope and the wild turkey. But in Kansas these forms of wild life disappeared as completely as the buffalo.

Because the deer and the elk were found largely in the eastern part of the state, their destruction by professional hunters started

*Idaho, 1864; Wyoming, 1871; Montana, 1872; Nebraska, 1875; New Mexico, 1880; South Dakota, 1883.

much earlier than the destruction of the buffalo. However, legislative policy toward these animals was more favorable.* The first protective legislation of the state, enacted in 1861, provided closed seasons on the deer and the wild turkey.[15] In 1868 the elk was included in the list of protected game, but in 1876 this animal was not mentioned. Apparently the time for protection had passed, as it had for the buffalo. The pronghorn, or antelope,† on the other hand, was not yet considered worthy of protection.

The game protection law was revised and reenacted in 1877, but in the act of that year no mention was made of the wild turkey or any of the grazing or browsing animals. Whether the earlier laws had come too late or whether their enforcement had been ineffective, it is evident that the deer, the elk, and the turkey could no longer benefit from protection. No further legislation was passed relating to large game until 1903, when the killing of antelope was prohibited for a period of five years.[16] In 1908 the prohibitive law was reenacted with the inclusion of the deer,[17] and again in 1911 an act was passed prohibiting the killing of deer or antelope for another ten years.[18] No protective law was in force between 1921 and 1925, but in the latter year complete protection of deer and antelope was made indefinite.[19] But these laws came too late to protect the native stock. In 1912 the state fish and game warden reported that large game animals had completely disappeared, and that the wild turkey had likewise became extinct.‡ The only useful purpose of protective legislation would be to aid in the propagation of imported stock.

LEGISLATION FOR THE PROTECTION OF GAME BIRDS

Living as they did in the midst of a great abundance of wild game, the early settlers of Kansas might well be expected not to

*In most of the eastern states the deer was the first beneficiary of protective legislation for wild game. At the time Kansas was admitted into the Union, 19 states had established closed seasons on deer. T. S. Palmer, *Chronology and Index of the Most Important Events in American Game Protection*, Bull. No. 14 of the Biological Survey, U. S. Dept. of Agriculture, 1912, pp. 20-25.

†The statutory names of animals, which are those commonly used and not the technical names, will be used in this article.

‡*First Biennial Report of the Fish and Game Warden*, 1910-1912, p 10. This report was not entirely correct: Deer occasionally enter Kansas even now from neighboring states. A very few antelope were still found in the southwestern corner of the state as late as 1930. In 1922 the Kansas warden reported that "there are two small bands of antelope, one remaining wholly in Kansas and one partly in Kansas and partly in Texas and Colorado." *Fourth Biennial Report of the Fish and Game Dept.* 1922, p. 11. This report stated that "every effort is being made to protect these animals," but failed to mention that from 1921 to 1925 Kansas had no law in force for the protection of either deer or antelope.

Lee Larrabee, chairman of the forestry, fish and game commission informs the writer that a band of antelope ranged along the Cimarron River in Oklahoma and sometimes entered Morton County in Kansas. He is of the opinion that these antelope quit ranging in Kansas about 1935.

Kansas is today the only state in which antelope were originally found in abundance but are now completely extinct. *Big Game Resources of the United States*, Research Report 8, of the Fish and Wild Life Service, U. S. Dept. of Interior, 1944, p. 25.

realize the need for a program of conservation. Yet the history of game protection policies in the older states prior to the time Kansas was admitted to the union provided warnings of things to come, as did also, no doubt, the rapid disappearance of large game in the eastern part of the state. Even in colonial times protective laws were deemed necessary in some areas, and by 1860, twenty of the 26 states east of the Mississippi River had established closed seasons on one or more species of wild game.[20] During the later years of the territorial period some of the far-sighted leaders in Kansas realized the need for laws to check the slaughter of game. A measure for the protection of quail and partridge in Leavenworth County was passed in 1861 by the last territorial legislature.[21]

AN ACT to provide for the Protection of Game.

Be it enacted by the Legislature of the State of Kansas:

SECTION 1. That it shall be unlawful for any person or persons to shoot, kill or trap, within this State, any prairie chickens, quails, partridges, wild turkeys and deer, between the first days of April and September, of each year. Shall not trap game between April and September.

SEC. 2. That any person convicted of violating this act, shall be fined in a sum not exceeding five dollars, and shall be liable for costs of prosecution. Shall be fined and pay costs of prosecution.

SEC. 3. That justices of the peace shall have jurisdiction of the offenses under this act, and all proceedings shall be in the name of the State, and shall be regulated as other criminal proceedings of a minor character, before justices of the peace. Justices shall have jurisdiction.

Fines paid into treasury for the use of common schools. SEC. 4. That all fines imposed under this act shall be paid to the justice before whom the proceedings are had, who shall, within thirty days, pay the same into the county treasury, for the use of the common school fund of the county in which the offense shall have been committed.

Twenty freeholders may render this law inoperative. SEC. 5. That, whenever the county board of commissioners shall have received a petition from at least twenty freeholders of such county, praying that this act be inoperative in such county, they may, in their discretion, so proclaim; and, after the date of such proclamation, no provision of this act shall be in force for twelve months.

When in force. SEC. 6. This act to be in force from and after its publication.

Approved May 10, 1861.

The first game laws enacted when Kansas became a state. From Laws of Kansas, 1861, Chapter 39. Courtesy Kansas State Historical Society.

In May of 1861 the first state legislature passed an act establishing closed seasons during the months of April to August, inclusive, for prairie chicken, quail, partridge, and wild turkey, as well as for deer. However, this act contained a proviso authorizing any board of county commissioners, on petition of twenty freeholders, to set aside the law in their county for one year.[22] Moreover, no state or local officers were made specifically responsible for enforcement of the law, with the probable result that no effective enforcement existed; but even so the prairie chicken was stricken from the protective law in 1865.[23].

An act of 1868 provided for closed seasons on upland game birds on a state-wide basis. The killing of song birds, including the dove, was prohibited, and the capture of game birds by the use of nets or traps was likewise made illegal. The closed season on quail was extended from five months to seven months. Also, in the attempt to promote effective enforcement, the act of 1868 made it unlawful to buy, to sell, or to have in possession any birds killed in violation of the closed season, and possession was declared to be *prima facie* evidence of violation. A penalty of $3 was prescribed for each bird killed or held in possession in violation of the law.[24] In 1876 the closed seasons were made longer and the penalty for violation was increased from $3 to $10 for each bird. But the snipe and the dove were no longer included in the list of protected birds. In further attempts to provide against violation and other unnecessary damage, this act prohibited the sale or willful destruction of wild birds' eggs, and it made railroad companies liable for penalties for the transportation of game that had been killed out of season; but like the act of 1868, this act permitted the use of nets or traps to catch quail and partridge on one's own premises.[25]

In 1877 the game law was again revised. This time it applied to birds only, and the basic form of the statute was changed from one of enumeration of protected birds to a general prohibition against killing of any birds except those enumerated. The enumerated exceptions were geese, ducks, hawks, owl, and snipe, on the killing of which there were no restrictions, and prairie chickens and quail, for which closed seasons were prescribed.[26] The practice of listing exceptions was continued until 1893 when the enumeration of protected birds was again restored.[27] In 1881 additional birds were included in the list of exceptions. On the other hand, the seasons on quail and prairie chicken were shortened. Penalties were increased to a minimum of $10 and costs.[28]

In the absence of any state agency responsible for the enforcement of game laws, there is little direct evidence of the extent of violation; but that violations were numerous and the method of enforcement ineffective is indicated by provisos which began to appear in the laws during the last two decades of the nineteenth century. For example, an act of 1883 authorized justices of peace to employ attorneys to act as prosecutors in place of county attorneys when the latter refused to prosecute, and to assess $10 in addition to other costs for payment of such attorneys. To offset this cost the minimum fine for violation was reduced from $10 to $5.[29]

In 1897 another attempt was made to compel public officers to enforce the game laws, this time by a declaration that all constables, marshals and police officers were game wardens, and that in cases of negligence or refusal to enforce the game laws, these officers would be guilty of misdemeanor and subject to penalties of from $5 to $100 for each offense, the same as the game law violators.[30] But in spite of this penalty legislation the state fish warden reported in 1904 that many complaints of illegal killing and shipping of game came to him from people who thought that he was also a game warden, and that from these complaints he was convinced "that thousands of ducks, prairie chicken and quail are being slaughtered out of season and shipped contrary to law."[31]

The next significant change in the laws relating to game birds came in 1903 when migratory water fowl—wild ducks, geese and brant—were added to the protected list. The killing of these birds was prohibited between April 25 and September 1 of each year. Closed seasons were restored for the dove and the plover,[32] and by another act of the same year the killing of quail and prairie chicken was prohibited in ten southern and western counties of the state for a period of three years.[33] Still another significant legislative enactment of 1903 was a statute that provided complete protection of Mongolian and Chinese pheasants for a period of four years. For the first time in Kansas, statutory reference was made to imported game birds.*

The acts of 1903 mark the last legislation enacted separately for game birds. In its next session the legislature established the office of fish and game warden and incorporated the fish and game law into a single statute.

**Laws of 1903,* Ch. 323. If pheasants were being distributed at the time this act was ıssed, the responsibility probably was taken by private individuals. The first distribution y the state game and fish department was apparently made in 1905. *Report of the Kansas 'ish and Game Warden,* 1907, p. 13.

BEGINNING OF FISH CONSERVATION POLICIES

A comparison of the early development of legislative policies regarding the conservation of fish and that regarding the protection of wild game reveals an interesting contrast in methods of approach. As pointed out above, legislation for the protection of game birds assumed the characteristics of general prohibitive laws. No state agency was established to supervise enforcements or to investigate the needs and the techniques of conservation; no specialized local enforcement agencies were provided for; and no program of propagation was undertaken. When evidence of neglect or refusal to enforce the game laws was brought to the attention of the legislature, it prescribed further penalty legislation, directed in this case against general enforcement officers.* Fish conservation, on the other hand, developed from a widely different kind of beginning. The first state law on the subject, enacted in 1877, provided for the appointment of a commissioner of fisheries, and directed him to make an investigation of lakes and streams to determine by what means they might be made more productive of fish. Except for a section that prohibited the catching of fish with seine during the spawning season, and certain provisions relating to the construction of fish ways in dams, the original act was concerned with propagation of fish, not with restrictions on the fisherman.

In all probability the state's course of action on fish conservation was a result of an earlier program undertaken by the federal government. Congress had established a commissioner of fisheries in 1871, and in 1873, $15,000 were appropriated for the cultivation and distribution of food fishes. Scientific work by this federal agency and by similar agencies in eastern states had led to the conclusions that fishing resources were decreasing and also that artificial propagation was feasible.[34] In Kansas, sportsmen were becoming concerned over the manner in which streams were being dragged with nets and fish taken by the hundreds in a single day.[35] The establishment of a state fish commissioner and the restriction on catching fish with seine reflect the development in the national government and the indignation of certain people over large scale commercial fishing in the state.

The first fish commissioner was appointed by the governor for a term of two years, and received, in addition to travel allowance of

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*Significantly, the prosecuting attorneys were not subjected to the penalty legislation as were constables, sheriffs and policemen. Instead, justices of the peace were authorized to employ attorneys when county attorneys refused to prosecute.

ten cents per mile, a compensation of $3 per day for a period restricted by law to fifty days in any one year. He was directed to visit the streams and lakes of the state "with a view to ascertain whether they can be rendered more productive of fish and what means are desirable to effect this object, either by restoring the production of fish in them or in protecting and propagating the fish that at present frequent them." The act authorized the commissioner to obtain fish for restocking of lakes and streams from the United States commissioner of fisheries or from private hatcheries. The state commissioner was also directed to see that the restrictive provisions of the law were enforced, and for that purpose he was authorized to call upon county attorneys for assistance.[36]

The primary factor limiting the work of early commissioners of fisheries was the lack of funds. The total expenditure for the first biennium, including the commissioner's salary and travel allowance, was $500. With this money he was unable to do more than receive a relatively small number of fish from the United States commissioner of fisheries for purposes of restocking. In 1880 the expenditures were a little less than $1700, and in 1885 an appropriation of $1800 was made, including $300 to meet a deficiency of the preceding biennium. The commissioner by that time was authorized to draw compensation for 150 days; but that amount of time was found to be inadequate, with the result that he was compelled to apply to the legislature of 1877 for an additional 45 days' compensation.*

Like the early game laws, the fish law of 1877 was amended on several occasions during the quarter century that followed. An act of 1883 prescribed penalties for killing or taking fish by the use of explosives,[37] and another act passed in 1886 prohibited the use of nets, seines and traps at any time, except on one's own property.† In 1889 the legislature prohibited the catching of bass, crappie, perch, and pike by the use of any methods other than rod, hook and line, but permitted the seining of other fish except during the months of May and June.[38] 1895 saw the first closed season imposed against the hook and line fisherman, the catching of bass being prohibited between April 1 and July 1.[39] In the same year the general prohibition against the use of fishing devices other than the hook and line was

*Although this claim was granted, the legislature did not change the 150 days limit prescribed in the general law, nor did it increase the appropriation for the next biennium.

†*Laws of 1886*, Ch. 108. Interestingly, another section of this act prohibited the removal of any object placed in a stream for the purpose of catching fish. The journals of the legislature contain nothing to disclose whether this section was designed to assist the law enforcing officers or whether, as seems more probable, it was a conflicting prohibition which reflected a lack of interest in fish conservation.

restored, and the ownership of any trap or net other than of the minnow net was declared *prima facie* evidence of violation of the law. Four years later the closed season on hook and line fishing was extended to include game fish other than bass, but the period was shortened to six weeks instead of three months. A penalty of from $25 to $100 in addition to costs, or imprisonment of not more than six months, was prescribed for each fish caught in violation of the law.[40]

The biennial reports of the early state fish wardens contained frequent references to the difficulties of securing effective law enforcement. Like the game laws, the fish laws were not popular. The county prosecutors were not interested in their enforcement, and deputy fish wardens and other local officers apparently preferred the good will of their neighbors to the praise of the fish commissioner and the $5 fee payable for each conviction.

Fish Propagation and Distribution

As pointed out above, the prohibitive legislation was not given primary emphasis in the fisheries program. Immediately after his appointment, the first commissioner, D. B. Long, made application to the United States commissioner of fisheries for stock, and in June of 1877, 1,000 young Atlantic shad arrived in Topeka for distribution.[41] As funds became available, increasing numbers of fish were imported and distributed. The emphasis that was placed on this phase of the commissioner's work is reflected in some of the early biennial reports, which were devoted almost entirely to the subject of fish culture. But the early commissioners, like the federal commissioners of fisheries and a large proportion of the citizenry, made the mistake of advocating the propagation of German carp. In the Fourth Biennial Report for 1883-84 the Kansas commissioner states that "never in the history of fish culture and propagation has any fish been more and better written up than the carp,"[42] and as late as 1890 Commissioner Brumbaugh reported that "German carp are well adapted to the waters of Kansas."[43] Throughout the decade of the 1880's the appropriation acts specified that money appropriated for fish propagation should be used to stock waters with "bass, German carp and such other food fish as may be attainable."[44] Partly because of the apparent success of stocking waters with carp, there was no movement for a fish hatchery during the 1880's. After noting the fact that some of the other states were making appropriations sufficiently large to maintain fish hatcheries,

Commissioner Gile reported in 1884 that "in Kansas I do not deem this a good or wise policy. First, it involves a large expenditure of money. Second, your commissioner can obtain all the kinds of fish adapted to Kansas waters cheaper and of a more ripe age than they can be produced in a hatchery. Third, native fish from a stream will bear transplanting better than fries from a hatchery."[45]

But it was not long before the tone of the recommendations was changed. Commissioner Sadler's report of 1896 contained the first critical reference to German carp,[46] and in 1902 a definite recommendation was made that steps be taken to destroy the carp in order to protect game fish.* And a parallel change in the recommendations occurred with respect to the fish hatchery. In his report of 1898 Commissioner Schultz recommended the establishment of a fish hatchery, and in 1900 Warden Wiley pointed out that 35 states had from two to five hatcheries and advised that similar steps were deemed wise for Kansas.[47] But the Kansas legislature of 1901 appropriated only $2800 for fish propagation and protection for the next biennium, as compared with $12,000 appropriated by Missouri, $15,000 by Nebraska, and $20,000 by Iowa.[48] In 1903, however, an act was passed authorizing the establishment of a fish hatchery and appropriating $1,000 for the undertaking.[49] This amount in itself would have been inadequate, but a gift of twelve acres of land from Pratt County made a beginning possible, and in another year the construction of the first state fish hatchery was under way.[50]

Growth of Administrative Machinery

Meanwhile the problems of fish culture and the enforcement of protective laws were reflected in the growth of the administrative agency. As already pointed out, the first fisheries commissioner was allowed compensation for a maximum of 50 days out of the year, and was given an appropriation of $500 for the biennium. The appropriations were increased to $500 per year in 1879, to $1,000 per year in 1881, and to more than $1500 per year for the period from 1883 to 1889; and by 1881 the commissioner was allowed to draw compensation for as much as 150 days.† But in 1889 the appropriations were suddenly cut off, and for the next biennium the commis-

Report of the Kansas Fish Warden, 1902, p. 4. Warden Dyche argued in defense of the carp during his administration a decade later (1909-1915). He was often accused, erroneously, of having brought this fish into Kansas, probably because he was instrumental in introducing it into certain new areas of the state. *Report No. 6 of the Kansas Fish and Game Department*, 1926, p. 65.

†The regular biennial appropriations for the years of 1883 to 1889 was $1500, but deficiency appropriations, some of them for compensation to the commissioner for services in excess of 150 days, permitted a maximum expenditure of about $1650 per year.

sioner was forced to operate on a balance of less than $400, which amount remained unexpended from the previous period.* The failure to provide funds was compensated for in part by a deficiency appropriation of $500 made in 1891, but for six years that followed the funds were cut to $500 a year. In 1897 the legislature again refused to appropriate money for the fisheries commissioner, though a deficiency appropriation was once more made by the succeeding legislature. Objection to the state agency was also reflected in bills introduced in the 1897 legislature to abolish the office. But two years later advocates of conservation succeeded in securing the passage of an act to provide for the employment of a fish warden on a full-time basis.†

The residence of the director of the Kansas forestry, fish and game commission at Pratt, Kansas, where the commission has its headquarters. The building was constructed during Professor Dyche's regime.

Seventh Report of the State Fisheries Commissioner, p. 7. The appropriation was not included in the ways and means committee bill of 1889. An attempt to reinsert the item in the bill was defeated in the House of Representatives. *House Journal of 1889*, p. 1280. It is possible that this refusal to appropriate reflected legislative concern over the failure of the earlier attempts to stock Kansas waters with Atlantic shad and salmon and also a growing dissatisfaction with the German carp.

†*Laws of 1899*, Ch. 142. Proponents, however, were not fully successful in their attempt to restore appropriations. The act of 1899 provided that the fish warden should receive a salary of $1,000 a year, but the appropriation was only $600 a year for the first biennium, and it was not until 1903 that a deficiency appropriation was made in order to pay the first fish warden his full statutory salary.

When the office of fish commissioner was established, local enforcement was supposedly a responsibility of the general police. This plan was obviously ineffective, and in 1886, and again in 1888, the commissioner suggested without success that the legislature provide incentives for enforcement by authorizing the payment to informers of at least one-half of the fines collected.[51] The difficulty of securing help of local officers was indicated also by another request made in 1888 that legislation be enacted to require county attorneys to prosecute owners of dams for failure to install fish ways. The installation of fish ways had been required by the original act of 1877, but enforcement was so ineffective that even as late as 1902 attention was called to the lack of a fish way at the Lawrence dam.[52]

In 1895 the legislature directed the fisheries commissioner to appoint deputy wardens in all counties which contained lakes or streams, and empowered these wardens to make arrests without warrants. The deputy wardens would receive fees of $5 for each conviction, together with the regular constable's allowance for travel. But these payments would be made only when obtained from costs assessed against violators of the fish law.[53] In 1896 Commissioner Sadler proposed the improvement of enforcement techniques by means which would involve the cooperation of local sportsmen. He suggested the formation of local fish and game associations and proposed that deputy fish and game wardens be appointed on request of associations which numbered fifty or more members. He also proposed to pay reasonable compensation to deputy county wardens.[54] When the fisheries law was revised in 1899 the legislature accepted Commissioner Sadler's recommendation in part, by providing that a county deputy warden should be appointed for any county in which a request was made by 25 residents. Enforcement continued to be ineffective, however. Deputy wardens who were sufficiently interested to assume responsibility for enforcement were difficult to find, and many people continued to catch fish with seine or by whatever methods they thought convenient, regardless of the law. Many of the deputies failed to report violations.[55] It was not until after the fish and game laws were consolidated under a single administration and adequate funds were made available that the enforcement began to be anything like effective.

BEGINNINGS OF AN EFFECTIVE CONSERVATION PROGRAM

The year 1905 marks the beginning of a new era in wild life conservation in Kansas. In that year the fish and game programs were coordinated under a single agency, with the establishment of the office of state fish and game warden.* Also the requirement of licenses for hunting provided a source of funds for administrative purposes and means for facilitating enforcement of the game laws.† In the same year, Chinese and Mongolian pheasants were introduced into Kansas for distribution.[56] Bag limits were established for the first time on game birds, and protection was extended to the first of the small animals, the red squirrel. In order to facilitate enforcement, the fish and game warden was authorized to inspect places where meat and fish were sold and penalties were prescribed for refusal to permit such inspection. Finally, the fish hatchery, which was already in operation on a small scale, was given added support when the legislature of 1905 appropriated the sum of $8400—more than had been granted for all purposes in any previous biennium—for the construction of a building and for other improvements. Doubtless because of a realization that wild life was being depleted, the general public was becoming aware of the need for protective legislation and for effective enforcement of such legislation, but without doubt the fact that adequate funds became available without annual legislative appropriations from the state general fund made possible the rapid expansion of the conservation program after 1905. The enactment of the hunting license law resulted in a marked increase in funds available for administration of the fish and game conservation programs. During the biennium prior to the new enactment, the total appropriations for the department were $2800; in the biennium that followed, the collections from license fees were $40,495.[57] Yet, as will be seen, the fish and game warden was soon to be forced to operate for another biennium without any legislative appropriation.

ADMINISTRATIVE ORGANIZATION, 1905-1927

Under the act of 1905 the state fish and game warden was appointed by the governor for a term of four years and received a salary of $1500 a year. His specified duties were the management

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**Laws of 1905,* Ch. 267. Commissioner Sadler had recommended such an agency in 1895, along with his proposed local fish and game associations. The recommendation was repeated in 1902 by Commissioner Haughy.

†*Ibid.,* Sec. 8. Hunting licenses were not required for hunting on one's own premises nor for hunting by club members on the premises of a hunting club.

of the fish hatchery, the supervision of enforcement of fish and game protection laws, and the distribution of fish and game. For purposes of law enforcement, he was authorized and directed to appoint one or more deputy wardens in each county in which ten residents made application for such appointments. The reduction from 25 to ten in the number of applicants necessary to authorize the appointment of

PROFESSOR LOUIS L. DYCHE
In addition to the material in the text, see page 320 for further information concerning Warden Dyche.

deputy wardens was followed by an increase in the number of counties for which wardens were appointed.

Although additional revenues were obtained from the hunting licenses, the state warden found himself without funds again in 1909. The legislature had failed to authorize the expenditure of moneys in the fish and game fund. Governor Stubbs obtained the services of Col. Thomas B. Murdock, who served without salary from July, 1909, until his death in November of that year. The

University of Kansas then came to the rescue. Shortly after Murdock's death the board of regents informed the governor that they would offer the services of Professor Louis L. Dyche as fish and game warden "for so much of his time as may be necessary to place the fish hatchery and the entire work connected with the position on a thoroughly scientific and economic basis."[58] The governor accepted this offer, and in December of 1909, Professor Dyche assumed his new duties. The salary of the warden was paid by the university, and other expenses necessary to maintain the fish hatchery were paid out of the governor's contingent fund.* In 1911, however, the legislature paid Col. Murdock's salary, provided for the reimbursement of the general fund out of the fish and game fund for moneys expended from the governor's contingent appropriation, and resumed the practice of appropriating the license fee revenues to the fish and game department.[59]

The arrangement whereby Professor Dyche was lent to the state by the university proved sufficiently satisfactory so that in 1911 the legislature placed the warden under the supervision of the university board of regents, and provided for his appointment by the governor with the consent of the senate.[60] Professor Dyche was continued as warden, and during his administration several notable improvements were made by the department. First in importance was the fish hatchery, which was completed within a short time after legislative appropriations were resumed. This hatchery, with 83 breeding, nursery and stock ponds, was hailed as the largest and best equipped hatchery of its kind ever to be built.[61] In addition, Dyche installed a new and more adequate accounting system, established a library and an experimental laboratory, undertook the publication of periodical bulletins on fish propagation and pond building, and by lectures and public statements secured an unusual amount of publicity about the work of the department and the conservation program.[62]

But Warden Dyche's dramatic career was not without its controversies. The hunters of the state were very critical, because, they contended, the warden used their money to construct and maintain an unnecessarily expensive fish hatchery.[63] Politicians, on the other hand, sought to control the funds of the department and the jobs made available because of those funds. The Democratic party gained control of the governorship in 1913, and some of its members

*The governor's contingent fund had been increased in 1909 from the usual $4,000 to $10,000 (Cf. *Laws of 1907*, Ch. 2; *Laws of 1909*, Ch. 5).

opposed the retention of an official brought in by a Republican governor. But Governor Hodges defended Professor Dyche, especially after receiving a favorable report from a commission appointed to investigate the management of the fish hatchery. However, the warden was the object of much criticism in the legislature during the last weeks before his death in 1915.

Professor Dyche's successors were not drawn from the university faculty, but the wardenship continued under the supervision of the board of regents and of its successor, the board of administration, until 1927. The warden was, however, in much the same position as the head of an independent department. The board of administration was consulted only on the employment of personnel and on major expenditures. But with the creation of the board of administration, the governor's control became more direct than before, be-

The administration building of the Kansas commission at Pratt. Here the departmental records are kept and its many activities controlled. The administration building also contains a small museum of mounted animals including nearly every specimen of migratory birds known to Kansas. One of the unusual features of both the director's home and the administration building is the attractive plantings of trees, shrubbery and flowers which have been maintained around the buildings in spite of the hot winds and dry weather of western Kansas. The 104 fish brood ponds, together with the buildings of the commission, lie east of Pratt and a mile south of U. S. Highway 54.

cause he was the chairman of that body and also appointed the other members.

Meanwhile the county wardens continued to be the only officers provided to assist in the enforcement of the protective laws. Attempts were made to encourage citizens to give assistance by authorizing the state game warden to pay rewards for information leading to the capture and conviction of violators,[64] and in 1915 the governor was directed to appoint two or more fish and game wardens in each county of the state.* But these wardens were unpaid except for the fact that they were entitled to $10 and certain travel expenses to be charged against violators upon conviction. It was not until 1921 that the governor was authorized, on recommendation of the fish and game warden, to appoint six special state deputy wardens who could be employed on salary bases.[65] These deputies were hired to serve largely as public relations agents rather than as police officials. Their job was to acquaint the public with the game and fish laws and to win public support for the program. In the words of Warden Doze, "they have been missionaries" for the department. Yet their appointment was followed by a sharp increase in the number of arrests and convictions under the fish and game law.[66] In 1925 the governor was authorized to increase the number of special deputies to twelve, if necessary, during the last four months of each calendar year, and in the same year the county deputy wardens were given state-wide jurisdiction.[67]

In answer to the hunters who had complained about the use of license fees for construction and maintenance of the fish hatchery, Wardens Dyche and Tegmeier had recommended the enactment of a law to require licenses for fishing also. The legislature, however, took a different course, by providing in 1915 that money used for the fish hatchery should not exceed $18,000 in any one year and that surplus funds in excess of that amount and general costs of administration should be placed in a special "game preserve fund", which was not to be expended until appropriations for its use were made by legislature.[68] But in 1919 about twelve thousand dollars were transferred from the game preserve fund to the general fund of the state, and in addition it was provided that thereafter 10% of all receipts from license fees should be credited to the general fund in order to pay costs of auditing and general supervision.[69] The diversion of

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**Laws of 1915,* Ch. 11. This provision involved two changes: appointment by the governor instead of by the state warden, and appointment for every county in the state.

this 10% to the general fund has been a subject of complaint from the fish and game department ever since.

Restrictions on Fishing and Hunting

In spite of the fact that game protection laws had been on the statute books for a half-century and fishing laws for a third of a century, the wild life conditions in Kansas in 1912 were highly unsatisfactory. The following description by Warden Dyche is suggestive of the ineffectiveness of early fishing and hunting legislation:[70]

> In former years, when the state of Kansas was new, it might have been considered a game state. The prairie lands were covered with herds of buffalos and antelope, and the wooded valleys and hills furnished shelter for many deer and elk. Wild turkeys were quite common in the wooded districts, and prairie chickens were found in great numbers, especially in the eastern part. At present conditions are changed. Large game animals have completely disappeared. Wild turkeys have likewise become extinct, and prairie chickens are confined to a few counties in the western part of the state and are threatened with extinction. About the only game animal that has held its own is the rabbit, and about the only game bird is the quail. Ducks and geese in former years were very common during the period of migration. Of late years, comparatively but a very few pass through the country. Kansas can not any longer be counted as a game state.

As Professor Dyche points out, these conditions were not entirely due to hunting and fishing. Large numbers of nests were destroyed by cultivation and by domestic animals in pastures, and the severe winter of 1912 had been particularly destructive of quail. But the fact remains that legislation for the protection of wild game had been notably ineffective.

The general trend in the years between 1905 and 1925 was toward reductions in bag limits, increases in the number of animals and birds protected, and new restrictions on the methods by which game might be taken. Warden Dyche, after having made a careful study of the game law, recommended several changes, and in 1911 the legislature enacted a new fish and game code. Under that code seasons were established on the principal fur-bearing animals of Kansas—raccoon, opossum, skunk, muskrat, mink—, and the beaver, like the deer and antelope, was given complete protection for a period of ten years. The eagle was protected indefinitely, and the closed term on imported pheasants was extended for another six years. Shooting of game birds was permitted only when they were in flight and only during the daylight hours, and shooting from motor boats was prohibited. But the right to take fish with seine was re-

stored, on the conditions that a permit was obtained from the state warden and that no less than three inch mesh was used.*

In 1913 all seasons on quail and prairie chickens were closed,[71] but four years later a fifteen day season was restored with bag limits on quail fixed at five in one day and ten in possession at one time. The open season was made applicable to pheasants also.[72] The seasons were shortened in 1919 to ten days, and in 1921 the open seasons on pheasants were discontinued and quail seasons were opened in alternate years only.[73] Other acts of 1921 and 1925 prescribed a number of changes in the fish and game laws. The fish law restricted each fisherman to a single line with not more than two hooks or a trot line with not more than 25 hooks, and also prohibited the use of trot lines in the immediate neighborhood of a dam or at the mouth of a stream or river.[74] In 1925 non-residents were required to have fishing licenses.[75]

An important chapter in the regulation of hunting opened in 1918, when the federal government enacted the migratory bird law. As early as 1900 Congress had taken steps to aid in the enforcement of state conservation laws by forbidding the shipment in interstate commerce of game animals and game birds taken in violation of state laws. But the act of 1918, which was designed to carry out the purposes of a treaty made with Great Britain in 1916 for the joint protection of migratory birds in Canada and the United States, marked the beginning of federal legislation to restrict the killing of wild game within the states. It also represented, in so far as Kansas was affected, the first instance in which seasons were fixed by administrative regulation instead of by legislative enactment. The United States secretary of agriculture, with the approval of the President, was authorized to issue rules and regulations prescribing open and closed seasons as well as other restrictions on the taking of migratory game birds. These regulations, which became operative early in the next decade, did not supersede state laws, except that hunting of migratory birds was legally permitted only when both federal and state seasons were open.[76]

Public Relations

One of the major problems faced by the authorities throughout the history of regulations has been that of building up favorable

**Laws of 1911,* Ch. 198. Warden Dyche made other significant recommendations that were incorporated into laws enacted years later. He recommended that fishing licenses be required, that the use of repeating and automatic guns be restricted, and that spring shooting be prohibited. *Kansas Fish and Game,* July-Aug., 1943, p. 5.

public sentiment toward the conservation program. As early as 1895 Commissioner Sadler had recommended the formation of local fish and game associations largely for that purpose, and Warden Dyche later carried on an extensive campaign of publicity, though sometimes in an atmosphere of verbal combat. Yet Warden Doze pointed out in 1924 that public support had been slow to develop in Kansas. He also called attention to the fact that "were it not for the hunters and fishermen, wild life in Kansas would be practically extinct," and with that fact in mind he had undertaken to organize these sportsmen as a means of building favorable sentiment. In 1923 and 1924 he held about fifty meetings and succeeded in organizing thirty county fish and game associations. At about the same time the Isaac Walton league came to Kansas and the Audubon Society of the state began to function, with the result that the state department had three associations to aid it in a program of education.[77]

FORESTRY, FISH AND GAME COMMISSION

The year of 1927 marked another major change in the organization of the state fish and game department. In that year the legislature placed the warden under the supervision of a fish and game commission and granted to the commission control over all finances and policies of the department. This change was due largely to the earlier activities of fish and game wardens and to those of the fish and game associations established under the sponsorship of Warden Doze. Then, too, the accumulation of surplus funds from hunting licenses provided an incentive to a program of development which the legislature deemed wise to place in the hands of a commission.

As early as 1922 Warden Clapp had suggested the formation of a commission in order to permit the establishment of more flexible game laws. He cited an example of the federal law under which the secretary of agriculture was authorized to issue regulations fixing seasons and bag limits on migratory birds, and expressed the view that similar authority in Kansas should be a matter for a commission and not for a warden.[78] Warden Doze, through a different approach, also laid the foundation for the establishment of a commission when in 1924 he advocated the enlargement of the water area of the state as a means of increasing the supply of fish and game.* This program won the support of fish and game associations, and in 1925 the leg-

*Warden Doze pointed out that there were at the time only 384 square miles of water area in Kansas. He advocated an increase in the water area, not only for the benefit of wild life, but also on the ground that an enlarged water area would produce an increase in rainfall. *Fifth Biennial Report of the State Fish and Game Department*, p. 6.

islature established a forestry, fish and game commission consisting of the governor, the state fish and game warden and three members appointed by the governor and the senate.[79] This commission exercised no authority over the fish and game department, but it was authorized to use certain fish and game funds in order to acquire title to land and waters for the purposes of constructing reservoirs, lakes, and fish and game preserves, and also to supervise tree planting and other improvements on public lands. During the months that followed its establishment the commission made a survey of more than fifty proposed sites for state parks and began to prepare plans for the establishment of lakes.[80]

It was obvious that a program such as planned by this new commission would have to be coordinated with the program of the fish and game department. Both the commission and the existing department drew their funds from the same source, namely, hunting and fishing license receipts; both were concerned with the development of game preserves and the propagation of fish and game. The legislature of 1927, therefore, recreated the forestry, fish and game commission and gave it full control over the department. Responsibility for the administrative management was retained by the state warden under the supervision of the commission, though he continued to be appointed by the governor with the consent of the senate. The commission itself consisted of the governor and three members appointed by the governor and the senate from the eastern third, the central third and the western third of the state, respectively.[81]

The most important new duty imposed upon the forestry, fish and game commission was that of building and maintaining state parks and state lakes. But with the reorganization came other significant changes in the law. In that year fishing licenses were required of residents for the first time.* Also, for the first time, the administrative agency was given authority to make regulations regarding open and closed seasons and regarding bag limits. The authority was negative only, in that the commission could not authorize the killing of game at any time fixed by law as a closed season, but the act marks the beginning of a new policy and of a distinction between the administrative responsibilities of the state fish and game warden and the quasi-legislative responsibilities of the commission.

*By this act of 1927 fishing licenses were required only of men between the ages of 18 and 70.

A Decade of Growth

A comparison between the status of the fish and game department in 1920 and in 1930 is indicative of the significant growth during the decade that followed the first world war.* In that period the gross receipts of the department increased almost ten fold, from $54,572 to $536,202 in a biennium. The personnel increased from 8 to 43, and in the latter year the department had 17 salaried deputy state wardens whereas none were employed in 1920. The state hatchery was enlarged from 91 ponds to 105, smaller hatcheries were built during the decade in Meade and Marion Counties, and brooding ponds were established at the Neosho and Ottawa County state parks. From a single game preserve, unfenced and undeveloped for conservation purposes, the facilities had grown to include six state parks with about 1,000 acres of lake surface; and in 1930 the Garden City game preserve was partly fenced and in use. Finally the enforcement of protective laws had been significantly tightened. In 1920 the department reported 43 convictions for violations of the fish and game laws. In 1930 there were 564 arrests and 511 convictions, and this in spite of the warden's statement that the most gratifying improvement was the change in public sentiment toward the state program.[82] The increase in the number of convictions came between the years 1921 and 1922, the time at which the first salaried deputy wardens were employed.

State Lakes and Parks

The outstanding development of the period that followed the reorganization of 1927 was the establishment of artificial lakes and state parks. Five parks were under construction in 1928 and three were almost completed. Another park was added in the next biennium, and counties were given authority, by an act of 1929, to establish parks and lakes.[83] Because of economic conditions, the park development program was temporarily discontinued during the first biennium of the 1930's; but by 1934 the federal government began to give aid through the civilian conservation corps and other public works programs, with the result that new parks were established in many areas of the state. The state commission's report of 1938 described twenty state parks in addition to the state fish hatchery, the buffalo preserve, a quail farm and a 3,000 acre state forest. Also in 1938 a new federal act providing for aid to the states for wild life

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*The comparison is interesting partly because the same man, Alva Clapp, held the office of state warden in 1920 and again in 1930.

restoration made additional funds available for the development of game preserves. With this aid the state fish and game department undertook the so-called Cheyenne Bottoms project, under which the commission has purchased somewhat more than 12,000 acres of land in Barton County and contemplates the purchase of a total of more than 18,000 acres and the construction of an 11,000 acre lake. The federal government will reimburse the state for a major part of the cost of this lake and game preserve project.[84]

Since 1941 the planned activities of the commission have been voluntarily curtailed because of wartime manpower needs, but it can be expected that major undertakings will be resumed after the restoration of peace. At the close of the fiscal year, 1944, the department had more than $275,000 in unexpended balances which will be available largely for purposes of park development,[85] and already the commission has under its supervision twenty-one state parks varying in size from 92 to 1,560 acres—parks that were developed and are maintained "without any cost whatever to the taxpayers of Kansas".[86]

Other Developments

In addition to its park projects, the commission has made considerable headway in its program of fish and game propagation. It has expanded the facilities for propagation and has improved the methods of distribution so as to reduce losses. Fish are now retained at the hatchery until they have reached sufficient maturity to care for themselves; the acquisition of three transport trucks has brought about a significant reduction in losses in shipment; and losses due to unwise stocking have been greatly reduced by reason of the fact that the department's employees now assume direct responsibility for planting of fish in approved waters instead of sending them upon application to residents.[87] A campaign against the pollution of waters by careless disposal of industrial waste has been carried on for almost twenty years, and recently the department, in cooperation with the state board of health, has conducted inspections of state waters and by other means has guarded the streams and lakes against pollution by oil field wastes and other brines.[88] Finally, the commission now has authority to make rules and regulations fixing seasons and bag limits on almost all fish and game covered by the protective law. This system permits a flexibility of policy not possible when changes could be made only when the legislature was in session.[89]

The two quail farms established by the department have been highly productive and are entitled to a large part of the credit for the restoration of quail to the point where open seasons are maintained annually. The pheasant has been successfully established in some parts of the state, after attempts which started almost 40 years ago and which at one time led the department to conclude that the project was a failure. Experiments have been conducted also in the propagation of the Hungarian partridge and the chukar partridge, but it is too early to draw any conclusions about the success of these projects.* Artificial propagation of prairie chickens was started during the middle 1930's, but was later abandoned.†

Public relations activities have been given special attention of the commission. The organization of local fish and game associations, which had been started by State Warden Doze in 1923 and 1924, was again undertaken by the department after 1939. In addition, a monthly magazine, *Kansas Fish and Game,* was published and distributed to approximately 3,000 sportsmen's clubs and individuals, although publication of this magazine has been discontinued temporarily because of war-time shortages. The use of motion pictures, including sound and colored pictures, has become a useful method of carrying the educational program to civic groups, schools and other organizations in the state. And finally, the department has made full use of newspaper releases, and this practice has met with favorable response from the newspapers of the state.

Administrative Problems

In a state that has operated under the spoils system it was to be expected that considerable pressure would be exerted to extend that system to a department with as much money as the forestry, fish and game commission has had at its disposal. But, on the other hand, this agency of government is financed by money received from a particular interest group whose members feel that they own the department and desire from it the full benefits of its service. This group, the hunters and fishers, have looked with disfavor on the more obvious instances of spoils politics in the department.

Because Kansas is largely a one party state, the effects of the spoils system have not been so noticeable or so serious as might

*At one time the department had concluded that the propagation of Hungarian partridges was a failure (Biennial Report of 1928, p. 72), but recent reports are optimistic about the success of establishing this bird in Kansas (Ninth Biennial Report, 1942, p. 14).

†Optimism prevailed in the Sixth (1936) and Seventh (1938) Biennial Reports, but in the Eighth Biennial Report (1940) the new commission told that the venture had been discontinued because it was "impractical."

have been the case under different conditions. Many of the employees have stayed in the service for relatively long periods. Moreover, relatively few changes in personnel were made during the Democratic administration of 1931 to 1933, with the result that little restoration was necessary when the Republicans returned to power. In 1937, however, the entire force of deputy state wardens was replaced, and only a few of the key technical men at the state hatchery and the game farms were retained. It was to be expected that this turnover would be followed by a like turnover when the Repub-

LEE LARAABEE
Chairman of the present forestry, fish and game commission; for over sixteen years connected in an official capacity with wildlife conservation activities in the state. (See page 321).

lican party returned to power in 1939. That year saw considerable administrative reorganization in the state government, and in many instances the principal incentive to such reorganization acts was the desire to hasten the restoration of jobs to the supporters of the Republican party. But, largely because of the insistance of the fish

and game associations, there was a genuine attempt to stabilize personnel in the forestry, fish and game department. The legislature revised the law with a view to eliminating spoils politics from the department in the future.*

The reorganization act of 1939 created a new forestry, fish and game commission, which is composed of six members appointed, from six designated districts of the state, by the governor and senate for four year overlapping terms. The act requires that three of these members be appointed from each of the two major political parties and that as vacancies occur, new appointments be made so as to maintain the party balance. Members of the commission receive a per diem allowance of $7.50 and travel expenses for time actually devoted to the work of the commission, but the per diem compensation cannot exceed $300 for a member in any year. No person is eligible to membership on the commission who has not held a fishing or hunting license for each of the four years immediately preceding his appointment.[90]

The director of the department is appointed by the commission and can be removed by it with or without cause. He is the administrative head of the department, and he selects all personnel with the approval of the commission. The act of 1939 provided that all employees should be selected on the basis of merit as determined by written or oral examinations, and that no employee would be permitted to participate in any political campaign, save to cast his vote. In 1941 the full-time personnel, except the director, were made subject to the civil service law and regulations.[91]

By the act of 1939 the county wardens were replaced by local "game protectors", who would serve without salaries and exercise authority similar to that of the earlier wardens.† These game protectors were originally appointed from among candidates nominated at meetings of license holders in the respective counties, but in 1943 the law was amended to eliminate the requirement of local nominations. Instead the appointments are made with the approval of the commission.[92]

*The turnover in 1939 was in fact almost as complete as in 1937, but the effects probably were not so serious, because many of the men who had served the department prior to 1937 were reemployed.

†Note that the term "warden" does not appear in the act of 1939. The state warden was replaced by a "director" and all deputy state wardens and county wardens were replaced by "game protectors." Historical associations have left an unfavorable stigma with the word "warden", and its use was considered inimical to good public relations.

IN CONCLUSION

Thus the administrative responsibility for the conservation of wild life has evolved through a period of eighty years, from an incidental duty imposed upon local sheriffs and police officers, and seldom performed by them, to a responsibility of a well-organized state agency supervised by a lay commission and directed by an experienced administrator. For the last two decades the state agency has been authorized to employ a small staff of game law enforcement officers, and more recently it has been empowered to determine open and closed seasons and to make other regulations for the protection of wild life. In the meantime an increasingly favorable public sentiment has tended to simplify the problems of enforcement. Always there are individuals who will violate regulations freely so long as they are not in danger of being apprehended, to be sure, and sometimes there are organized groups that seek to gain special privileges to the exclusion of the general public; but on the whole, the people recognize the necessity of the conservation program and desire its effective enforcement.

During the last two decades the wild life population of the state has experienced a general recovery. Partly because of more effective state enforcement than in earlier years, partly because of successful propagation and distribution, and partly because of federal participation in the protection of migratory birds and in restoration of wild life, Kansas is once more becoming a game state. But the state's history has shown that game conditions are not solely the results of restrictions on hunting, fishing and trapping. The supply of wild life has risen and fallen for other reasons: because of weather conditions, diseases, the availability of land for breeding and feeding quarters, and destruction by means of fire, cultivation, and other activities of man not directly concerned with the wild game as such. The reclamation movement at the opening of the twentieth century, combined with the lax hunting regulations of that time, was a serious threat to waterfowl; and the extensive wheat cultivation that began in Kansas during the first world war destroyed the homes of many upland game birds. Kansas has had particular difficulties in preserving its wild life, because less land has been left untouched by man in this state than, perhaps, in any other. The population is not dense, but it has been said that not a single square mile of land has been left untouched by man.[93] Cultivation and settlement have made survival difficult for those forms of wild life that shy away from man, and for those that live and propagate in the

open prairies. Consequently, the development of the lake and park program within the last two decades may have been a more important step toward the restoration of wild life than all of the hunting and fishing and trapping regulations of the preceding half-century.

The great game animals of the nineteenth century have disappeared, and they cannot be restored in anything like their former numbers. The buffalo can be no more than a show animal, pastured and cared for on a prairie zoo. The deer and the antelope can possibly be restored. In fact, the former occasionally makes its appearance in Kansas along the borders of states in which this animal is still preserved.* The development of state parks and other forests may provide areas into which deer can be reintroduced successfully. Reintroduction of antelope may be possible if peacetime marginal lands are withdrawn from cultivation and if the state secures the cooperation of ranchers.† Recently the state fish and game department has begun to experiment in the reintroduction of the wild turkey. A few have been introduced and liberated in sections where the bird was known to thrive a half-century ago, but the results of the experiment are not yet known.[94]

Wartime shortages of manpower, of firearms and ammunition for civilian use, and of motor fuel and tires, have resulted necessarily in a decline in the amount of hunting. This fact, however, does not mean that wild game is on the increase. The activities of propagation and distribution have been curtailed, also; and, probably because of the shortages of ammunition, the wartime years have seen a considerable increase in the number of predatory animals in Kansas, especially the coyote. Moreover, the food requirements of war once more call for extensive cultivation of lands, and a consequent reduction in nesting areas for upland birds.‡

But what of the post war outlook? As already pointed out, the commission will have adequate funds to resume its state park programs, and federal aid funds will be available for wild life restoration. Moreover, our experiences after the first world war suggest that the return of peace will be followed by new interest in hunting and fishing, and consequently by new demands for the preservation

*Missouri had an open season on deer in 1944 after a six year closed period. It was estimated that there were 16,000 deer in that state, of which about 700 were killed during the season. *Kansas City Star*, February 11, 1945, p. 3B.

†Claude W. Hibbard of the Museum of Vertebrate Paleontology at the University of Kansas believes that the deer and the antelope should be reestablished, "A Checklist of Kansas Mammals, 1943", *Transactions of the Kansas Academy of Science*. Vol. 47, p. 61-88, 86-87 (1944).

‡Recently the forestry, fish and game department has not been optimistic about the future of the prairie chicken. *Tenth Biennial Report*, 1944, p. 11.

and restoration of wild life. Probably more than ever before wild life conservation will be a matter of direct concern to the general public. As is probably true already, the great majority of all hunting and fishing licenses will be sold to farmers, workers, and business and professional men who find time to hunt and to fish occasionally in the neighborhood of their own homes. These, and not a class of sportsmen that can be set apart from the general public, are the people who finance the conservation programs and whose interests are to be given first consideration.

Appendix

Kansas Commissioners, Wardens, Directors—1877-1945

The following men have headed the fish and game departments since the first fish conservation act was passed in 1877.[95]

D. B. LONG, 1877-1883.
The first fish commissioner of Kansas and the pioneer of them all. An early advocate of a state fish hatchery, but later became an advocate of "economical" propagation of German carp.

W. S. GILE, 1883-1885.
He also advocated distribution of carp, and advised against a state fish hatchery on the ground that it would be an unnecessarily expensive undertaking. Advocated severe penalties for violation of fish laws in order to "effectively put a stop to them".

S. P. FEE, 1885-1889.
Another advocate of carp, Fee also spent a great deal of time trying to get owners of dams to install fish ways.

JOHN M. BRUMBAUGH, 1889-1891.
Served without any appropriation. Collected information from other states regarding their expenditures for fish conservation and propagation.

J. W. WAMPLER, 1891-1895.
Advocated better fish protection laws, and strict enforcement. Also continued Brumbaugh's attempt to get appropriations comparable to those of other states.

O. E. SADLER, 1895-1897.
A man who pointed the way to future policies. He advocated the creation of an office of fish and game warden, and the organization of county fish and game associations to assist in enforcing conservation laws and in building public support for the program. He was opposed to further distribution of carp, and he advocated the construction of a fish hatchery.

DR. J. W. SCHULTZ, 1897-1899.
The last of the fish commissioners, Dr. Schultz worked without any funds. Yet the number of arrests and convictions reported by his county wardens was relatively high.

GEO. W. WILEY, 1899-1902.
As the first full-time state fish warden ,Wiley received $600.00 a year, but in 1903 the legislature voted to pay him the balance of his statutory salary of $1,000 a year. Wiley was a strong advocate of a state fish hatchery.

J. W. HAUGHEY, 1902-1903.
When informed by the United States commissioner of fisheries that he could get only one of the three carloads of fingerlings for which he applied, Haughey had all of his county fish wardens apply for stock and also solicited fish through the congressmen. He recommended that steps be taken to destroy the German carp, and also that fish and game interests be consolidated.

D. W. TRAVIS, 1903-1909.
As the last of the fish wardens, Travis started construction of the first state fish hatchery. In 1905 he became the first state fish and game warden. He started the importation and propagation of Mongolian and Chinese pheasants. He was the first warden to have funds derived from the sale of hunting licenses.

COL. T. B. MURDOCK, June to Nov., 1909.
Like Brumbaugh and Schultz, he had to serve without funds, for the legislature had failed to authorize the expenditure of funds from hunting licenses. The governor came to the rescue by authorizing the use of part of his own contingent fund, but he was critical of the way in which Col. Murdock used the money.

LEWIS L. DYCHE, 1909-1915.
Loaned by the University of Kansas in order to keep the work going in spite of the legislature's failure to appropriate funds, Professor Dyche stayed on until his death. He had what was probably the most dramatic career of any of the wardens. He completed the Pratt hatchery, which was then the largest of its kind ever built; and like Sadler, he pointed the way to many changes in policy that came into operation years later. He probably introduced the idea of non-partisanship into the department, and for that he was disliked by members of both political parties.

W C. TEGMEIER, 1915-1919.
Served in a period that was obscured by the first world war. His first biennial report had the appearance of a Dyche report, and indicated relatively effective enforcement for his time. In 1917 and 1918 activities of the department were evidently curtailed, and the biennial report, which was little more than a financial statement, was hidden away in the reports of the board of administration.

ALVA CLAPP, 1919-1923.
Was the first state warden to have the assistance of salaried deputies. This addition to the staff was followed by a sharp increase in the number of arrests and convictions.

J. B. DOZE, 1923-1929.
Perhaps no other period in the history of wild life conservation in Kansas is marked by as many new developments as that in which Doze was state warden. State parks and lakes, fishing licenses, the fixing of seasons by administrative regulations, and other major improvements were started during his administration.

ALVA CLAPP, 1929-1931.
Might be called the "Grover Cleveland" of the department, because he was the only warden who served two terms separated by an interval out of office. See 1919-1923.

J. P. CAMMACK, 1931-1933.
During his short term in office Cammack made a strong campaign against the "diversion" of 10% of the license fees to the general fund, and also against stream pollution. Because of economic conditions the state park program was somewhat curtailed while he was in office.

W. G. STRONG, 1933-1935.
Prior to his death in office, Strong was indefatigable in his efforts to have the Cheyenne Bottoms accepted as a federal migratory waterfowl refuge. He also started the experiment in artificial propagation of prairie chickens. Because of federal aid the state park and lake program was resumed on a large scale during his term.

FRED L. HANS, 1935-1937.
Served during the years of drought. Introduced the chukar partridge into Kansas.

L. C. WEBB, 1937-1939.
The last of the state fish and game wardens, Webb obtained a new location for further attempts at artificial propagation of prairie chicken. An attractive but off-size report for his term was written by Roy Wall, member of the commission.

GUY D. JOSSERAND, 1939-1944.

The first director of the forestry, fish and game department appointed by the newly established lay commission. Worked successfully for closer cooperation between sportsmen and the commission, and also started a number of projects made possible by the "Federal Aid in Wildlife Restoration Act". He resigned to return to his farming and cattle interests in western Kansas.

DAVE LEAHY, 1944 -.

The present director. He is a career man, having been employed in the department, except for a short time, since 1928, and having served as assistant director under Josserand. His record as director lies in the future.

ON THE COMMISSION

LEE LARRABEE, 1925-1931, 1933-1937, 1939 -.

Not a warden, not a director, yet the champion of them all in length of service, Mr. Larrabee has been a member of three differently organized forestry, fish, and game commissions and is the chairman of the present one. He has made significant contributions to Kansas park and wildlife conservation programs, and has also been called upon for assistance by the fish and game department of at least one other state.

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(86) *Tenth Biennial Report,* p. 17.
(87) *Ninth Biennial Report,* 1942, p. 10.
(88) *Tenth Biennial Report,* 1944, p. 6.
(89) *Laws of 1943,* Ch. 171.
(90) *Laws of 1939,* Ch. 290.
(91) *Laws of 1941,* Ch. 358.
(92) *Laws of 1943,* Ch. 173.
(93) *Fifth Biennial Report of the Kansas Fish and Game Department,* 1924, p. 5.
(94) *Eighth Biennial Report,* 1940, p. 5.
(95) The data included in the appendix, were taken from the biennial reports of the department, from the *Senate Journals,* and from the files of *Kansas Fish and Game.*

Hope is the sunrise of our tomorrows and the standard bearer of progress; therefore, we would violate our allegiance to wild life and the countryside should we not herewith express our hopes for the future.

All those who may be charged with the responsibility of our wildlife resources should continually strive to peer into the hours of unborn time and anticipate the changes that our tomorrows are bringing to us over the trackless plains of the future. Yet of this we may now be certain, the value of recreation afield will increase as the modernity of our present civilization progresses.

Further, we may be certain that the wildlife resources of the state can, if well managed, abundantly underwrite all reasonable needs for administration and an encouragingly adequate program for greater development of this community resource of recreation. There lies in the resource itself the genesis of funds for maintenance and expansion.

Therefore, it is our sincere hope that the commonwealth of Kansas unfailingly exerts its sovereign power in demanding that its wildlife resources be wisely manager.—From the *Seventh Biennial Report of the Kansas Forestry, Fish, and Game Commission,* 1938.

Science leaves us faith in the worth and dignity of man. In spite of weakness and imperfection, man is the highest product of a billion years of evolution. We are still children in the morning of time, but we are attaining reason, freedom, spirituality. The ethics of mankind is not the ethics of the jungle or the barnyard. In the new dispensation men will no longer be restrained from evil by fear of hell or hope of heaven, but by their decent instincts and their high ideals. When love of truth, beauty, goodness, of wife, children, humanity dies in us our doom will be sealed. But it will live on, somewhere and somehow.

Science leaves us hope for the future. Present conditions often seem desperate; pessimists tell us that society is disintegrating, that there will never be a League of Nations, that wars will never cease, that the human race is degenerating, and that our civilization is going by the way of ancient Egypt, Assyria, Greece, and Rome. But though nations have risen and fallen, and cultures have waxed and waned, the major movements of human history have been forward. After civilization had once been attained, it never completely disappeared from the earth. The torch of culture was handed on from Egypt to Greece and from Greece to Rome, and from all of these to us. One often hears of lost arts and civilizations of the past, but the best elements of any culture are immortal.—Edwin Grant Conklin in "Science and the Faith of the Modern," 1925.

The Editor's Page

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ROBERT TAFT, *Editor*

The brief statement made in an editorial of the last issue, concerning the social obligation of the scientist, is a theme which I shall continue to stress as long as I am editor of the *Transactions;* for in my judgment it is the most important problem confronting the profession of today. In my salad days, when I was green in judgment—to borrow a phrase from Shakespeare to brighten this page—I believed that anyone who did not work sixteen hours a day on his specialty, to the exclusion of all else, was not worthy of notice; not only did I think this the proper behavior, I was taught that it was the only correct way. Some of those who believe in this mode of life are still teaching this doctrine but their days are numbered for—fortunately—many of the younger members of the profession are of their own accord realizing that this isolationist attitude is no longer defensible. It is granted that training in most scientific professions requires an intense concentration of effort over a long period of time. Nevertheless, time must be taken from the training of the rising generation of scientists to inculcate within them the obligation to regard themselves as part of society with functions and responsibilities to assume in that society; and not to think of themselves as a group apart from the rest of the world with little interest in its troubles and affairs.

The training period of the young scientist may have to be made longer or, perhaps, we must be satisfied to graduate him with a smaller knowledge of his specialty. Whatever the solution of the teaching problem involved, I am convinced that we, as a profession, must take our part in the affairs of state and nation.

There is a growing feeling among many scientists that these social obligations must be assumed; my voice is not the only voice crying in the wilderness. For more powerful voices than mine I would refer the interested reader to the following three articles, all of recent origin, which consider this same subject — either directly or indirectly — from various viewpoints:

Arthur H. Compton, "What

Science Requires of the New World", *Science,* Jan. 14, 1944.

H. A. Spoehr, "Some Responsibilities of Science", *American Scientist,* January, 1945.

Harlow Shapley, "A Design for Fighting", *The American Scholar,* Volume 14, No. 1, 1944-45.

* * *

Edwin O. Stene, the author of the featured review in this issue of the *Transactions,* was born and brought up on a farm in central Minnesota, the state

DR. EDWIN O. STENE

of ten thousand lakes and a greater number of tall fish stories. These last two facts are probably not irrelevant in Mr. Stene's career and certainly not so far as the subject of his present review goes. In fact, Professor Stene contends that one of his earliest childhood recollections was the catch of an eight-pound northern pike from one of the ten thousand lakes; a catch that was followed very shortly by another one of thirteen pounds. Kansas fishermen, satisfied with eight-ounce bluegills or one-pound bass, will be inclined to look upon the alleged childhood exploits of Mr. Stene as simply other members of the Minnesota tall-fish-story family. The editor, however, having personal knowledge of Mr. Stene as a man of impeccable virtue and veracity, believes every word of his recollections. Whether the thirteen-pound pike had anything to do with stimulating Mr. Stene's interest in acquiring greater knowledge of the outside world isn't altogether clear in the editor's mind, but the fact remains that after finishing high school, he entered the University of Minnesota.

After receiving his bachelor's degree from Minnesota, Mr. Stene taught for five years in South Dakota high schools and recalls, among the pleasant experiences of his South Dakota days, a considerable number of successful pheasant hunting expeditions—hunting made possible, incidentally, by conservation practices.

Mr. Stene returned to the University of Minnesota in 1929 for graduate training and, in 1931, received his doctorate from that institution in political science. His teaching experience includes intervals at the University of Minnesota, the University of Cincinnati, and the University of Kansas. He has been at Kansas now for some ten years where he has specialized in the teaching and study of public administration and where he is now in charge of the bureau of governmental research. He has become especially interested in the history of Kansas administrative agencies and has supervised the work of a number of graduate

students in several studies in this field. The preliminary work, for example, in collecting much of the material upon which Dr. Stene has based his article in this issue of the *Transactions* was done by one of his students, Mr. Mervel P. Lunn. Mr. Lunn presented this material in a master's thesis to the University in 1940.

Other publications of Dr. Stene include contributions to Hedger and others, *Introduction to Western Civilization,* 1940; Eldridge and others, *Development of Collective Enterprise,* 1943, and to the *American Political Science Review,* December, 1940, "An Approach to a Science of Administration"; and many others.

Political science, Dr. Stene contends—as the title of one of his publications just cited suggests—is a science, in the sense that it deals with the collection, classification, and analysis of facts relevant to the government of human society in the hope that predictions can be made that will aid in the progress of mankind. Such processes of thought, all will agree, are scientific in scope; further, all, of whatever profession, should be in sympathy with the ultimate objective of political science as expressed in the sentence above.

* * *

The *Transactions,* a journal of general science, is a never-failing source of education and enjoyment to the editor, who received his training as a physical chemist; but a new and broader world of scientific study has become apparent since he assumed office some four years ago. The topics of investigation upon which reports are submitted are always a source of amazement. The article by Dr. Guhl in this issue is a case in point. The study of the social behavior of fowls was an undreamed of possibility to the editor; yet upon reading the article, one readily discerns the importance of such studies when they can eventually be carried to the human realm (a few studies have already been made in this direction). The effect of hormones and the adjustments and readjustments possible from systematic studies of social behavior of the lower animals, carry an import that may eventually be of tremendous significance to the human race. Readers of the *Transactions* who are not familiar with this type of investigation should read Dr. Guhl's paper and also the comment by Professor Hutchinson in the same field (including mention of some of Dr. Guhl's previous work) in the *American Scientist,* October, 1944 (p. 292).

* * *

Mr. Ernest Mullin has about as much to do with the production of the *Transactions* as any one and yet his name has not previously appeared in these pages. Stop a moment, then, and give Mr. Mullin a bow. Ernie is the linotype operator who has set in type most of the material that has appeared in the last four volumes of the *Transactions;* he not only sets the type but helps make up the page forms as well. Much of the credit for the neat appearance of our past volumes is due to the care and skill of

Mr. Mullin.* In addition to these talents, Ernie is a born diplomat as he claims he actually likes to read the manuscripts he sets. Occasionally something baffles him for a moment as occurred in the case of the last issue which included Dr. Treitel's article. Dr. Treitel made rather extensive use of the calculus but, nothing daunted, Ernie went to work and improvised characters to set up the equations in the Treitel article. Quite a feat, in the editor's judgment, for a printer who seldom is called upon to set complex mathematical equations.

When Mr. Mullin is rushed for time some of our manuscripts are parceled out to other operators. For instance, to hurry things along in the last issue, Dr. Lane's article on fossil fishes was given to a fellow worker of Ernie's to set. When the operator had struggled through the paleontological mysteries of the paper, he returned the manuscript and linotype slugs to Ernie with the remark, "That's the damndest fish story I ever read" —or at least that's the version of the judgment that will have to appear on these chaste pages. Authors would do well to remember, therefore, that their efforts are judged, not only by the editorial board but by other critics as well, before the articles finally appear in print.

* * *

Dr. Otto Treitel, mentioned in the paragraph above, has several times been a contributor to the *Transactions.* Doubtless his personal history is unique among Academy members. Born in Germany and educated in large part in that country, he received his doctorate from the University of Heidelberg in the field of physics. Later he did research in plant physiology at Heidelberg under Dr. Ludwig Jost. When the Nazis came into power he was thrown into a concentration camp for some time. After this experience, together with his wife, he made his way to Sweden with part of his belongings. From Sweden Dr. Treitel came to this country in October, 1939. He taught several years in a small Wisconsin school but is now teaching mathematics and physics at the great colored school, Fisk University, Nashville, Tennessee. For several summers in recent years he attended the University of Michigan Biological Station and there became acquainted with Dr. F. C. Gates of Manhattan who interested him in the work of the Academy. At Dr. Gates' suggestion he began the several studies already reported in the *Transactions.* All members of the Academy will join in the wish that his days in this country will be far brighter and happier than they were in doomed Nazi Germany.

* * *

The western plains of America have long held a peculiar fascination for many people. It is a fascination that has been enhanced for multitudes, since the middle of the last century, by blood and thunder stories of Indians and cowboys; and a sub-

*Another linotype operator who has worked on the *Transactions* and did an excellent job was Wesley McCalla. McCalla now has a leave of absence from The World Company, and is with the First Army in Germany.

ject that has been grasped and exploited time and time again by the motion-picture industry. Even to the serious student of the west and its culture—despite the artificial atmosphere created by writers, artists and movie scenarists—there is an irresistable lure in the contemporary accounts of travel and exploration in the early history of the Great Plains. At the present day, however, there is being compiled a history of the scientific exploration of the west, which although not as easy nor as alluring reading as the earlier accounts, is doubtless of greater importance. The *Transactions* takes no little pride in publishing its share of these modern accounts. Since 1941, we have published some dozen papers dealing with various aspects of the Great Plains and the relations of its geographical character to its plant life. Most of these papers have been the work of Academy members at Fort Hays Kansas State College, notably Dr. F. W. Albertson and Mr. Andrew Riegel, both of the botany department of that institution. A paper by Dr. Albertson will be found, for example, in this issue and one by Mr. Riegel in the last (December, 1944) issue; in addition, a number of Dr. Albertson's students have made similar contributions to our scientific knowledge of the Great Plains. The illustrations in some of these articles are particularly noteworthy as they should help to convey some realization to our eastern friends of the actual appearance of the Plains. Especially interesting in this connection are many of the illustrations appearing in the Riegel paper cited above. Others may be found by leafing through volumes 44, 45, and 46 of the *Transactions;* an especially striking one being a photograph of trees along the Smoky Hill River in Ellis County, Kansas, which appeared in an article by Mr. S. B. Griswold (*Transactions,* volume 45, p. 101, 1942).

We are especially pleased that further contribution to our scientific knowledge of the Plains has been promised by President L. D. Wooster of Fort Hays Kansas State College. President Wooster will prepare one of our featured review articles on some phase of the general topic "Birds and Mammals of the Western Plains."

* * *

We are also pleased to report that Dr. E. V. McCollum, professor of biochemistry at the Johns Hopkins University, is preparing a review for the *Transactions.* Dr. McCollum writes that the article will deal with applied nutrition in the light of present-day knowledge.

In those vernal seasons of the year, when the air is calm and pleasant, it were an injury and sullenness against nature not to go out and see her riches, and partake in her rejoicing.—John Milton, 1644.

Scientific News and Notes of Academy Interest

After considerable delay because of rulings of the O.D.T., the seventy-seventh annual meeting has been set with certainty for April 14th at Manhattan, Kansas. Because of the large membership at Manhattan, a very sizeable meeting can be held. Officers, other members of the council, committee chairmen and committee members, as well as members appearing on the scientific programs will not raise the limit of members attending (from out of town) to the fifty prescribed by the O.D.T. All such members should make a special effort to be present in order to carry out the necessary and important business confronting the Academy. For members who cannot be present attention is again directed to the fact that papers for the *Transactions* can be submitted at any time; a procedure which, if followed by all members, will materially aid in prompter publication of manuscripts accepted.

We are pleased to announce that at a meeting of the Board of Regents of the Smithsonian Institution, held on January 12, 1945, Dr. Alexander Wetmore, a member of the Kansas Academy, was elected to the post of Secretary of the Institution. This place was left vacant by the resignation on June 30, 1944, of Dr. Charles G. Abbot, who asked to be relieved of administrative duties in order that he might devote himself to his researches. Dr. Wetmore, who has served as Assistant Secretary of the Institution since 1925, has accepted the post with the understanding that at some later time he will be permitted to return to research work.

Dr. F. C. Gates, for ten years the former editor of these *Transactions* and professor of plant ecology at Kansas State College, Manhattan, has been elected to the editorial board of *Ecological Monographs* for the period 1945-47.

The Reverend Leroy Hughbanks of Osborne, Kansas, the only blind member of the Academy, has been working for many years collecting data on waxes used in phonograph records and upon the history and science of sound reproduction and recording. Many of such data are of especial value in the preparation of recorded material for the blind. Rev. Hughbanks has recently finished a book *Talking Wax* which will soon be published by the Hobson Press of New York. The book deals with the history of the phonograph.

Dr. Roger C. Smith, well known to Academy members, has returned to his duties at Kansas State College, Manhattan, after a year's leave of absence spent in Washington. For the first few months in Washington, Dr. Smith passed judgment on applications for student

deferments in the fields of agriculture and the pre-medical sciences. The remainder of Dr. Smith's time was spent in connection with the preparation of the national roster of scientific and specialized personnel. Dr. Smith reports that there are at present over 445,000 names on the roster.

Miss Eunice Kingsley, assistant professor of botany at Kansas State College, Manhattan, is on leave of absence and is teaching this year in the high school at Great Bend, Kansas.

Dr. Charles E. Lane, associate professor of zoology at the University of Wichita entered the armed forces as a second lieutenant, August, 1942. His work has been with the army air forces working in aviation medicine. At the present time he is stationed at Mitchell Field, New York, where he is director and coordinator of the high altitude training unit. Professor Lane was responsible for setting up the experimental air chamber at Mitchell Field and assisted in the preparation of the pamphlet, "Physiological Aspects of Flying", Technical Manual, T. M. 1-705, War Department. In 1943 he was advanced to the rank of captain. Professor Lane resigned from the faculty of the University of Wichita, effective February 2, 1945.

In the past few years, the Kansas State Board of Agriculture has published four important volumes on various aspects of the flora of Kansas: *Wild Flowers in Kansas, Trees in Kansas, Grasses in Kansas,* and *Weeds in Kansas.* With the exception of *Trees in Kansas,* all of these works were prepared by Dr. F. C. Gates of Manhattan; *Trees in Kansas* was the work of Dr. Gates and Mr. Charles A. Scott. The first two volumes on the above list are now, unfortunately, out of print but copies of the last two can still be obtained without charge by addressing Mr. J. C. Mohler, Secretary, Kansas State Board of Agriculture, Topeka.

Dr. Paul G. Murphy, associate editor of the *Transactions* and professor of psychology of Kansas State Teachers College, Pittsburg, has been appointed dean of administration of the college, the appointment becoming effective July first of the current year. Dr. Murphy will teach during the spring quarter in the psychology department of Ohio State University at Columbus.

A foundation for industrial research has been established at the University of Wichita as the result of $450,000 contributed by local business and industry. Started by voluntary subscriptions of $100,000 each from Beech Aircraft Corporation and Cessna Aircraft Company, the fund is expected to reach the half-million mark soon. The program calls for expenditure of the original fund within the next ten years, thus providing a substantial annual sum which will be used in the main to supplement the present research staff and to improve present laboratory facilities.

As President W. M. Jardine

points out, Wichita is one of the nation's vital war production areas and following the war will face the huge task of maintaining employment in its readjustment to peace-time economy. Many sub-contractors and scientific men who came to the city to engage in war work wish to remain—some to carry on with industries already established and others to engage in new fields of enterprise. Many problems involving industrial research have arisen in these industries. The primary purpose of the foundation is to maintain facilities and personnel for research and testing work in this connection.

Applied and pure research will be conducted in aeronautics, engineering, agriculture, chemistry, physics, geology, petroleum, and marketing analysis and outlets. Fellowships and scholarships will be established whereby outstanding students may engage in graduate study pertinent to the work of the foundation. Research on problems submitted to the foundation will be undertaken for industrial firms at their expense, with all results being turned over to the requesting concern.

Dr. R. Stanley Alexander, assistant professor of physics and astronomy at Washburn University, has been granted leave of absence, beginning March first, to take a position with the Western Electric Company in the field of electronics and radar. After eight weeks' training in radar school, he will be stationed in one of the coastal cities as an inspector of radar equipment upon naval and commercial vessels.

Mr. B. Ashton Keith, a member of the Academy now living in Washington, D. C., and the author of the article, "A Suggested Classification of Great Plains Dust Storms" which appeared in a recent issue of the *Transactions,* has prepared an extensive report on the control of floodwaters of the Missouri River basin for the U. S. House of Representatives Committee on Irrigation and Reclamation. The report will be found in "Hearings before the Committee on Irrigation and Reclamation, House of Representatives, Seventy-Eighth Congress, Second Session, H. R. 4795", December 1, 1944.

Washburn University, in cooperation with Stormont and Christ's Hospitals in Topeka, will inaugurate a cadet nursing program beginning about March first. The cadet nurses will spend one term on the Washburn campus, where they will receive training in chemistry, nutrition, and biology. The remainder of the training course will be taken in the two hospitals.

Dr. Carroll W. Bryant of the physics department of the University of Wichita left the University August 1, 1943, to accept a position as an operations analyst in the operations analysis section of the North African Airforces. He continued this work in Italy in the Mediterranean Allied Airforce. In September of 1944 he returned to this country to become the head of the operations analysis section of the aeronautical division of

the Bureau of Standards at Washington, D. C. Dr. Bryant is expected to return to the University of Wichita at the end of the war.

Some confusion has arisen concerning the membership fee of the Academy. The very nominal fee of $1.00 goes solely to the support of the *Transactions,* whose publication would not be possible unless we had other sources of income than our membership fee. A fee collected in 1944 entitles each member to all issues of volume 47 of the *Transactions,* which include those of September and December, 1944, and March, 1945. The 1945 membership fee will entitle each member to all the issues of volume 48, namely June, September, December, 1945, and March, 1946. Quarterly publication began too late in 1944 to publish a June, 1944, issue.

Professor Kenneth Andrew, professor of physics at Friends University, Wichita, is absent on leave for service to his country.

Dr. Arthur A. Case, assistant professor of veterinary medicine at Ohio State University, Columbus, writes that as a Jayhawker he sometimes feels lost among the Buckeyes. For this reason, the *Transactions* are doubly welcome. Each issue keeps him in touch with Kansas and he can also follow the work of his friends. Dr. Case is working in the field of veterinary pathology and his duties include both teaching and research.

Dr. William H. Mikesell, professor and head of the department of psychology at the University of Wichita, has been on leave of absence with the U. S. Army since October, 1942. Dr. Mikesell entered the service with the rank of first lieutenant and has since risen to the rank of captain. He is in charge of the testing program at the Ft. Logan Induction Center, Denver, Colorado.

A new source of fuel oil in Kansas has recently been announced by the State Geological Survey of Kansas. Investigation of the shale deposits of the state has revealed that the Bourbon shale in Labette and Neosho Counties is an oil shale. The oil shales so far studied consist of hard black platy shales in beds as thick as 30 feet. Laboratory tests show that some of these Kansas oil shales will yield more than 20 gallons of oil and 1,500 cubic feet of gas per ton. It is estimated by Survey geologists that at least 500 million tons of the oil shale can be obtained from open pits and quarries in the Bourbon shale layer in Labette and Neosho Counties alone. This quantity of shale contains more than 125 million barrels of oil and 500 billion cubic feet of gas. Although it will probably not be economically possible to produce oil from the oil shale at the present time, the oil shales, nevertheless, constitute an important oil reserve and in the future when our oil and gas reserves decline they will become an important economic fuel resource of the state.

Ensign Robert G. Chapman, formerly a member of the zoology department, Kansas State College, Manhattan, has recently completed a course in the communications school at Harvard University. Within the past few weeks Ensign Chapman visited in Manhattan while on the way to the west coast where he will report for further assignment.

The State Geological Survey, the departments of geology, of petroleum engineering and of mining engineering at the University of Kansas have recently moved from Haworth Hall to their new headquarters in the Mineral Resources Building (Lindley Hall) at the southwest corner of the campus.

Mrs. Ruth O. McKinley has been elected to succeed the late Mr. W. D. Royer as instructor in science in Wichita High School East. Mr. Royer, for several years a member of the Academy, died some months ago; his obituary appears in this issue of the *Transactions*.

Bulletin 52, Part 1 of the State Geological Survey, *Reconnaisance of Pleistocene Deposits in North-central Kansas* by C. W. Hibbard, J. C. Frye and A. Byron Leonard, all members of the Academy, is available for distribution from the State Geological Survey, Lawrence, for a mailing charge of ten cents. The bulletin published in February, 1944, describes the lithology and physiography of Pleistocene deposits and lists also known vertebrate and invertebrate fossils found in the deposits.

Dr. Charles E. Burt, who recently resigned as professor of biology at Southwestern University, Winfield, has established the Quivera Specialty Company at 4010 W. 21st Street, Topeka. The newly organized company will deal in biological and other natural history specimens, curios and publications.

Dr. W. H. Schoewe, associate editor of the *Transactions* and past president of the Academy, will devote the next six months to research and field studies of the Wabaunsee coals for the State Geological Survey of Kansas. The State Geological Survey is making an intensive study of the coal resources of the state. Field work in the Wabaunsee coals was started last summer by Dr. Schoewe. A previous study of the Thayer coal was made by Dr. Schoewe and published by the State Geological Survey as Bulletin 52, Part 3, *Coal Resources of the Kansas City Group, Thayer Bed in Eastern Kansas*

Dr. Stuart E. Whitcomb is absent on leave from the department of physics at Kansas State College, Manhattan, to work in the ballistic research laboratory at the Aberdeen Proving Ground, Maryland.

Prof. Stephen D. Durrant, of the department of biology, University of Utah, Salt Lake City, arrived at the University of Kansas early in February to give the initial semester's work in the

new course, Biology 1, which is being offered at the University of Kansas beginning in March. This course will be prerequisite to other courses in botany, entomology, physiology and zoology.

Mr. Blaine E. Sites after teaching for 18 months in the service programs at both Kansas State College, Manhattan, and the University of Kansas, is now science instructor in the Salina High School, Salina, Kansas.

Wilbur S. Long, once an active member of the Kansas Academy of Science, died at Moab, Utah, on October 19, 1944, at the age of forty-one. Mr. Long at the time of his death was district conservationist over Grand and San Juan Counties, Utah. He was especially interested in birds and bird life and was the author of "A Check-List of Kansas Birds" which appeared in volume 43 (1940) of these *Transactions*.

Philip S. Riggs, associate professor of physics and astronomy at Washburn University, was recently granted his doctorate by the University of California.

Dr. W. J. Baumgartner, managing editor of the *Transactions* and chairman of the committee on state aid, reports that the bill appropriating six hundred dollars for the work of the Academy for each of the next two years has passed both houses of the 1945 state legislature. We are grateful for this aid and can assure the legislators that the money will be spent wisely and carefully in the scientific interests of the state.

A fellowship for the promotion of research on oral vaccines has been established in the biology department at Kansas State Teachers College at Pittsburg by the William S. Merrell Company of Cincinnati. The work is being supervised by Dr. J. Ralph Wells, head of the department. Three studies have been completed by graduate students, and further work is being carried out by Dr. Wells and Prof. George Ruggles. Dr. Wells reported on the progress of the work at the annual meeting of the Missouri Valley Branch of the Society of American Bacteriologists held in Topeka last December.

Dr. Clement H. Sievers, associate professor of psychology at the University of Wichita, has been on leave of absence since October, 1942. He was commissioned a first lieutenant and stationed in the Adjutant General's Office, Washington, D. C., where he was working on the standardization of tests which the army uses. He has since been transferred to New York City. Since going to New York City he was promoted to the rank of captain.

Dr. Hazel Fletcher, for over five years a member of the textiles department at Kansas State College, Manhattan, has resigned to accept a position in textiles research with the Bureau of Home Economics, U. S. Department of Agriculture, Washington.

Professor William H. Mathews, past president of the Academy and a member of the physical science department at Kansas State Teachers College at Pittsburg, has been appointed coordinator of vocational rehabilitation education there by President Rees H. Hughes.

Kansas State College, Manhattan, has very recently received a grant of $1,000 from the Institute of American Poultry Industries, Chicago, to be used in the development of an early feathering strain of high producing White Plymouth Rock chickens. The research project will be carried out under the direction of Dr. D. C. Warren, geneticist of the poultry department.

Dr. Lilian Phelps, formerly a member of the biology department at Washburn University and more recently in public health service in New York, died recently in New York City. Her obituary will appear in volume 48 of these *Transactions.*

Dr. Marshall A. Barber, an honorary member of the Academy, visited the University of Kansas, his alma mater, during the week of February 12-17. Dr. Barber, an outstanding authority on malaria, spoke before a number of University organizations during his stay on the campus and renewed many old friendships as well. His work on malaria control has taken him to many countries over the world and, although he is in his seventy-seventh year, he anticipates a professional trip to Guatemala in the coming summer.

Changes of address of Academy members should be promptly reported to the Managing Editor. Your thoughtfulness in making such reports will help ease the Managing Editor's worries now that the *Transactions* appears four times a year rather than once. If the address given for you in the membership list in this issue is incorrect, please help us by reporting the correct address. Notice of failure to receive an issue should also be sent in as soon as possible.

—if a square meter were assigned to each man, and if all men were put close to one another, they would not occupy the area of even the small Lake of Constance between the borders of Bavaria and Switzerland. The remainder of the earth would remain empty of man. Thus, the whole of mankind put together represents an insignificant mass of the planet's matter. Its strength is derived not from its matter, but from its brain. If man understands this, and does not use his brain and his work for self-destruction, an immense future is open before him in the geological history of the biosphere.—W. I. Vernadsky in the *American Scientist,* January, 1945.

Some Observations and Experiments on Social Behavior in the Domestic Fowl

A. M. GUHL
Kansas State College, Manhattan

Interest in social organization among vertebrates stems from the initial observations by Schjelderup-Ebbe (1922, 1935) on birds, much of which was concerned with the so-called peck-order in the common domestic fowl. Recent studies of both an observational and analytical nature have expanded into the several classes of vertebrates and under field and laboratory conditions. Chickens serve as useful animals for experimental treatment and have received much analytical attention in studies of social behavior by Allee (1938, 1942, 1943) and his associates.

This avian hierarchy is based on what has been called peck-rights, in which the relative social position of each hen is determined by the number of birds it pecks. The truly dominant bird pecks all in its flock without being pecked in return, and the bottom bird is pecked by all. The rest may form a straight-line peck-order between them, although pecking triangles may occur. The social order tends to be straight-line in small flocks, is relatively stable among hens, is formative among pullets, and may tend to change among cocks. In mixed flocks all of the cocks usually dominate all of the hens. When strange birds are brought together for the first time, fights occur between the individuals until a decision is reached, but not infrequently some submit passively. Upon the outcome of these initial pair-contacts the social order is based, as a beaten bird will thereafter avoid the hens to whom it lost in the introductory contest. This aggressive behavior and the factors which make for success in initial encounters between hens have been analyzed by Collias (1943, 1944).

The relative influence of hormones to aggressiveness have been subjected to tests. Low ranking hens injected with the male hormone, testosterone propionate, by Allee, Collias and Lutherman (1939) rose to top position in each flock so tested. Epinephrine had no effect (Allee and Collias, 1938); thyroxin had no demonstrable influence on success in initial pair-contests (Allee, Collias and Beeman, 1940); and the female sex hormone, estradiol, did not produce as striking results as the male hormone but tended to act, probably

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indirectly, in the opposite direction (Allee and Collias, 1940). Psychological factors have also been under investigation.

It is obvious that penmates must recognize each other, and the indications are that head furnishings play a major role in recognition. When we (unpublished data) surgically removed combs from hens, they were attacked as strangers upon return to their pens the second day after the operation. A control was isolated concurrently for the same period of time with each of the dubbed birds, and in each test was not attacked when it simultaneously rejoined its flock with the operated penmate.

A hierarchy based on peck-rights suggests that the individuals must show discriminatory behavior, which poses the question as to whether these birds react to social position. Using a discrimination cage developed by the social psychologist Murchison (1935) we tested two small flocks composed of hens and cocks; and the results showed that neither sex reacted to social position, i.e., they were unaware of a social order *per se.* The discriminations were notably influenced by individual differences, which indicated that the birds acted and reacted to individuality and to former pair-contact experience, and that each bird developed special habits in relation to every member of its flock. The cocks tended to show a definite sex discrimination by approaching the hens more frequently than they did the roosters. The hens appeared to react selectively toward the individual cocks in relation to the differences in the behavior of these cocks toward the hens (Guhl, 1942).

The significance of this social organization has two major aspects: (1) May high social rank be associated with survival values from the viewpoint of the individuals? (2) Does an organized flock display any group advantages as compared with an unorganized or less well integrated group?

It has been shown by Masure and Allee (1934) and Collias (1944) that birds ranking high in the social order have precedence to food and display greater freedom of the pen. Hens from the upper half of the social organization lay more eggs than their less aggressive penmates (Sanctuary, 1932).

In tests of several months duration we (Guhl, 1941; Guhl, Collias and Alee, 1945) found that when roosters were introduced alone into a pen of hens, the rate at which they trod showed no definite relation to their social position among the cocks in the pen of males from which they were taken. Nor was the frequency at which the hens were mated indicative of their levels in the peck-order of the

females. This means that the best fighter among the cocks was not necessarily the one with whom the hens bred most freely. However, when four roosters were placed in a relatively small pen with seven hens the dominant cock would attack the others when they courted or trod the hens. In a rather short time the inferior cocks learned to ignore the hens and to remain at a distance from the dominant cock; and the hens learned to avoid these beaten roosters. Under these conditions most of the matings were by the top ranking cocks and in extreme cases the inferiors were psychologically castrated. These observations showed that cocks of high social status have precedence to mating. It is of interest to note that Scott (1942) reports a similar situation among the sage grouse (*Centrocercus urophasianus*) in the wild.

In contrast with the roosters, the hens typically showed no reaction to copulations occurring about them. The impression was given that the aggressive cocks pursued any hen while the hens, more passive than the cocks, determined by either receptive or avoiding reactions which rooster was the most successful in mating with them. The hens appeared to regulate to a more or less degree which cock, when and how often treading may occur. The factors which influence the sexual reactions of the hens have been suggested but need further study.

An experiment was set up (Allee and Guhl, 1942; Guhl and Allee, 1944) to compare differences between socially organized flocks of hens and similar flocks undergoing constant reorganization. Forty-nine White Leghorn hens were divided at random into three control flocks of 7 each which were permitted to establish and maintain peck-orders; and into a fourth flock of 7, the longest resident of which was replaced daily or every other day from a group of 21 isolated hens. By means of this rotation these alternates, after 21 days of isolation, met their former flockmates as strangers and the social order was kept in a state of flux. After 38 weeks the alternations were made between three experimental pens, one flock continued as controls, and 21 hens remained in isolation. This latter procedure continued for 16 weeks.

All penned flocks were fed two times daily and the length of the feeding time was adjusted so as to insure a constant maintenance of body weight and egg production for the controls. The amount of food consumed by each flock was determined by weighings. Body weights were taken weekly and when hens were transferred to and from isolation. Social activity was measured by tabulations of

pecks and threats observed at feeding time. Egg production was determined by trapnesting.

A comparative analysis at the outset of the experiment and during the initial weeks when the controls were in the process of becoming organized, showed that the control and the experimental groups did not differ significantly and were therefore statistically similar samples of the population. After the adjustment period the hens in the flocks undergoing a constant reorganization pecked each other more than did the members of the organized flocks; the former also consumed less food. This inverse relationship of the frequency of aggressive social activity, as measured by pair-contacts, with avian economics was reflected in relative biological success as expressed in gain or loss of body weight and in egg production. Hens lost weight while members of the unsettled flock of alternates; controls and isolates tended to gain weight. The experimental hens laid fewer eggs during their residence in the socially unstable pen than when these same individuals were in isolation, or than did their neighbors in the well established control flocks. These results suggest that integrated flocks of hens as compared with unorganized flocks may possess advantages which, if they occurred in nature, may have survival values.

During the weeks when replacements were made from isolation it was observed that a hen was typically at the bottom of the ephemeral peck-order on her first day of residence and she gradually rose to *alpha* position when her term of residence was concluded. A few highly aggressive individuals gained top rank on admission to the pen, and some hens failed to climb very high on the social ladder. The correlation of days of residence with social position was highly significant, which demonstrated that hens may possess seniority rights. However, when the transfers were made from pen to pen this relationship became less pronounced although still significant statistically. This difference was due, among other factors, to the fact that rotations occurred in some instances before certain individuals had been separated sufficiently long enough to forget former penmates. It was also obvious that some very aggressive hens became conditioned to meet these difficult social conditions while the most unaggressive hens became frustrated in the 16 week shuffle.

A number of interesting major problems are still open for investigation, some of which are in progress. The scientific interest in such studies is becoming more evident with attempts to fit them

into a phylogenetic series in comparative social behavior (Allee, 1938, 1942, 1943; Tinbergen, 1939; Redfield, 1942; Collias, 1944).

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College Success in Relation to Age of Entrants

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This study deals with the college success of students in relation to the age of the entrants. Success for this study is measured chiefly by marks obtained in various college courses. The per cent that remained in college until graduation and length of attendance for the entire group, however, may also be considered as partial measures of success.

The basic data comprising this study are presented in Table I. It will be noted that for this study the students were divided into five age groups for each sex. Group I consisted of students whose age at college entry was 15 or 16 years; group II consisted of students whose age was 17 years; group III, 18 years; group IV, 20 and 21 years, and group V, 23 years or more. Students of ages 19 and 22 were omitted to give a larger spread in the group samplings and to avoid a tedious repetition of data.

The students whose records were used in this study were those who entered the Emporia Teachers College between September, 1930, and January, 1939, inclusive. The original plan called for an equal number of cases in each group for each sex, but for the men it was impossible to obtain an adequate number of the youngest group and also the oldest group. The cases for each group were selected so that as nearly as possible the groups were equated in respect to year of college entry and decile rank on the battery of entrance tests annually administered by the college.

For the purpose of interpreting Table I, it should be observed that the plan of converting the letter marks into a numerical index was used. For this purpose one point was allowed for each hour of A, two for each hour of B, three for each hour of C, four for each hour of D, and five for each hour of F. In this manner an average mark of C would be represented by 3.00, an average mark of B by 2.00, and an average mark of D by 4.00. Hence, the lower the mark as expressed in Table I, the higher was the average.

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TABLE I.—Comparison of Scholastic Achievement of Students of Various Ages at College Entry.

Sex	Group	N	Ages	Median Mark Index	Q	P. E. Median
Men	I	40	15 & 16	2.65	0.46	0.090
	II	76	17	2.94	0.47	0.068
	III	82	18	2.74	0.41	0.057
	IV	68	20 & 21	2.79	0.47	0.071
	V	48	23 & over	2.56	0.50	0.090
Women	I	81	15 & 16	2.61	0.40	0.056
	II	77	17	2.60	0.41	0.058
	III	77	18	2.56	0.46	0.066
	IV	82	20 & 21	2.47	0.38	0.052
	V	81	23 & over	2.44	0.38	0.053

Read Table Thus: For the forty men of group I, ages 15 and 16 at college entry, the median mark index was 2.65; the Q was 0.46; and the P. E. Median was 0.090.

It will be noted for the men, the highest average mark was obtained by Group V, the oldest group; the second in order was Group I, the youngest group; the eighteen-year group came third; the twenty to twenty-one-year group, fourth; and the seventeen-year group, fifth.

For the women the median marks were exactly in reverse order from the ages. The oldest students at college entry made the highest marks and the youngest made the lowest marks.

The general belief in respect to college success of students of various ages is diversified. Some believe that if students come to college while very young they will squander their time and not succeed in making very high marks because of the fact that socially they are not as well prepared for the college situation as are those of more mature years. Conversely, others believe that if students of fifteen, sixteen, or seventeen years of age come to college they must be considerably brighter than the average students who enter college and, therefore, they should register a higher degree of college success. Some persons may also believe that the very young students, because they are socially less well adjusted and are more or less of the introvert type, should devote more attention to their studies and, therefore, attain higher scholastic success. The data herein presented, however, are not clear cut in either direction. Although for the women the average marks run in direct order of ages, the differences between the sixteen and seventeen and between the seventeen and eighteen-year groups are too small to warrant conclusions.

The reliability of the difference between the median marks obtained by the various groups were computed but for none of the comparisons was the difference large enough to be statistically significant.

In respect to persistence in attendance at college, the data are

more conclusive. The data concerning the number and percent remaining in college until graduation are shown in Table II. For the women it will be clearly observed that the younger they were at entry the longer they remained in college; or in other words, the

TABLE II.—The Number and Percent of Each Age Group Graduating.

Group	Men N	Men %	Women N	Women %
I	15	37.5	25	30.9
II	15	19.7	14	18.2
III	11	13.4	11	14.3
IV	11	16.2	7	8.5
V	11	22.9	4	4.9
TOTAL	63	20.1	61	15.3

Read Table Thus: Of the original 40 men who entered college in age group I, 15 or 37 5 per cent graduated; of the 81 women, 25 or 30.9 per cent graduated.

greater was the percent graduating from college. A number of explanations for this condition may be suggested. In the first place, girls who enter college when very young are less able to find suitable employment after one or two year's attendance. Hence, the tendency to remain until graduation is enhanced. In the second place, these girls probably feel that if they stay until graduation they still are young enough for the marriage market after they graduate. On the other hand, those who enter, say from twenty years upward, probably feel that if they stay until graduation and then teach several years they may have greater difficulty in the marriage market. In looking at the percentage of men graduating, it will be observed that the differences from Group I to Group V were not nearly so marked as with the women. Moreover, a larger percentage who entered college at any age remained until graduation than did most of the women groups. The youngest group, however, had a distinctly higher percentage graduating than any of the other groups.

Table III gives additional data in respect to persistence in attendance of the various age groups. These data are the average number of semesters of attendance of the groups which were studied. It will be noted that the youngest men group registered the highest median semesters of attendance; the youngest women group, the second highest; the oldest men group, the third highest; and the third women group, the fourth highest average. In view of the fact that these data are comparable to a considerable extent to the persistence of attendance data presented in Table II, no further discussions are deemed essential.

TABLE III—Median Number Semesters College Attendance of Each Age Group.

Group	Age	Men	Women
I	15 & 16	5.8	4.9
II	17	3.9	3.7
III	18	3.5	4.1
IV	20 & 21	3.9	3.6
V	23 and over	4.2	3.7

Read Table Thus: The median number of semesters of college attendance of age group I was 5 8 for the men and 4.9 for the women.

TABLE IV.—Median Number of Children per Family of Each Age Group.

	Size Family	
Group	Men	Women
I	2.7	3.7
II	3.5	3.7
III	3.6	4.4
IV	4.4	4.6
V	4.7	4.7

Read Table Thus: The median number of children per family of age-group I was 2.7 for the men and 3.7 for the women.

TABLE V.—Percent of Students in Each Age Group Whose Parents (One or Both) Had Some Education Beyond the Secondary School.

	Percent	
Group	Men	Women
I	50	31
II	33	35
III	29	30
IV	34	23
V	15	15

Read Table Thus: In age-group I one or both of the parents of 50 percent of the men and of 31 percent of the women had some education beyond the secondary school.

TABLE VI.—Percent of Honor Students in High School of Each Age Group.

	Percent	
Group	Men	Women
I	20	33
II	15	40
III	21	34
IV	23	20
V	2	11

Read Table Thus: In age-group I 20 percent of the men and 33 percent of the women were honor students in high school.

TABLE VII.—Percent of Students in Age-Groups I and IV Whose Parents Belonged to Each of Seven Occupational Divisions.

	Men		Women	
	Age Groups			
	I	IV	I	IV
Farmers	21	49	47	58
Skilled laborers	31	21	13	14
Laborers	10	2	8	4
Government Employees	3	....	5	1
Salesmen and clerks	8	8	9	9
Merchants	13	15	8	10
Professions	15	5	9	5

Read Table Thus: The parents of 21 percent of the men of group I and of 49 percent of group IV were farmers

Although having only indirect bearing on the main topic of this study, another question that presented itself in this connection was that pertaining to size of families of the various age group students. These data are presented in Table IV. The question is: What relationship existed between the age of the students who entered college and the size of family from which they came? Did those who entered at a low age come from smaller or from larger families? In general it will be noted that the younger the students were, the smaller were the sizes of their families. This result might indicate that families with fewer children have brighter children, except that an attempt was made to equate the groups in respect to ability. The reason for the differences then must be sought elsewhere. It is possible that small families had better means of sending the high school graduates to college immediately upon graduation than did families with a

larger number of children. Many of those entering in the highest age groups probably deferred entering college in order to earn funds to defray college expenses. This experience, coupled with the natural maturity of the added years, may also account for the small advantage exhibited in respect to average college marks.

In Table V are presented data in regard to the education of the parents. It will be observed that, as a general rule, more persons who came to college at a younger age had parents one or both of whom had some education beyond the secondary school. For the men in particular it will be observed that fifty per cent of the fifteen and sixteen-year-old group had parents in this category. In view of the fact that college entry at the age of fifteen or sixteen is first of all dependent upon high school graduation at an early age, it is possible that educated parents have a certain influence in getting their children through the grade school and high school at an early age. Whether they have them enter grade school at a younger age or whether they are more helpful to see that they have a chance to become accelerated, or at least not to become retarded, cannot be stated from the data at hand. Some influence, however, must be operative in connection with this condition.

In Table VI are presented the percent of honor students in high school of each age group. In the four highest groups of ages, there apparently was little difference from one group to the next in this respect. The group composing the oldest age division, however, was marked by the smallest percentage of students who were honor students in high school. Whether they were the slow type who graduated from high school at a later age or whether they did not immediately come to college upon high school graduation cannot be said. In all probability the former was at least a contributing factor; at least that is what one would expect. If they were mediocre students in high school, they probably took somewhat longer to complete the work of the school, and at the same time they would be less likely to be honor students. On the other hand, if reference is made to Table I, it will be noted that for the women, these same students made the highest average marks in college.

In Table VII we have data pertaining to the occupational division from which the students in Group I and Group IV came. It will be noted that in general a larger percentage of the students in Group IV came from the farmer division. A larger percentage in Group I came from the professional division. It also happens that a larger percentage of students of Group I came from the laborer and from

the government employee divisions, and for the men also from the skilled laborer division. Although these data are interesting, they are not highly significant. The significant point to note is that no age group had a monopoly in this respect. Age Group I students came from each of the occupational divisions; and likewise, Group IV students, with a single exception, came from each of the occupational divisions.

Conclusion

1. For both sexes the oldest student group at college entry achieved the highest scholastic success.
2. For the men the youngest student group ranked second in achievement.
3. For the women each successive age group from youngest to oldest ranked higher in respect to scholastic success.
4. For each sex a higher per cent of the younger groups remained in college until graduation than of the older groups, but the tendency was more marked for the women than for the men.
5. For both sexes the younger students remained in college longer than the older students.
6. The younger students at college entry came from smaller families than the older students.
7. More of the parents of the younger students at college entry had enjoyed some education beyond high school.
8. More of the older students at college entry came from rural families than did the younger students. Of the latter a few more came from professional families than did the former.

Research in Waxes

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The ordinary concept that a wax is an ester of long chain monohydric alcohols and long chain acids does not embrace most substances we prefer to call waxes. The definition of Chibnall is that a wax is a product that contains long chain aliphatic compounds, hard or becoming hard by hydrogenation, fat soluble, and containing no glycerides. This definition, of course, suggests that waxes are not so simple in composition as we have always thought them to be. Recent work has shown that most data compiled on the physical properties of well-known waxes are in error, as well as are data on wax constituents.

Waxes occur in the three natural kingdoms of matter, but we have been primarily interested in animal and vegetable waxes that contain true waxes, i.e., esters of long chain aliphatic alcohols and acids. Table I shows the occurrence of some common waxes; Table II, the common constituents of waxes; and Table III, the chief constituents of more common waxes.

TABLE I—Occurrence of Waxes.

Candelilla Wax; Carnauba Wax; Apple Peel Wax	Epidermal excretions.
Beeswax (secretion?); Lac-Wax; Cochineal Wax	Insect waxes of uncertain
Leaf Waxes— Cabbage; Brussels Sprouts; Lucerne; Wheat; Cocksfoot	Not epidermal or excretions, but an integral part of protoplasm of mesophyll.
Other Kinds— Sperm; Bird (feathers)	

TABLE II—Some Common Constituents of Waxes.

Carbon Content	*Alcohol*	*M. Pt.*	*Acid*	*M. Pt.*	*Diff. in M. Pt.*
26 - 27	Ceryl	80°	Cerotic	83°	3°
28 - 29	Montanyl	84°	Montanic	87°	3°
30 - 31	Myricyl	88°	Melissic	91°	3°
Paraffins—26, 27, 28, 29, 30, 31, 37, 35 (37?) carbon atoms					

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TABLE III—Chief Constituents of Some Waxes.

Paraffin Wax	Mixture of saturated hydrocarbons
Carnauba Wax	Myricyl Melissate (true wax)
Candelilla Wax	Resin Paraffin Esters of uncertain composition
Beeswax	Ceryl Cerotate Myricyl Melissate
Lac Wax	Laccerol Laccerate

In the isolation, purification, and identification of natural products, the goal of the investigator must be that of obtaining the compounds in the condition in which they existed in the original state. However, investigations upon fats and waxes, with the exception of the recent work of Boemer and others (1,2), have proceeded according to the time-honored method of the separation of the wax or fat into its saponifiable and non-saponifiable fractions. Of course, this method does not elucidate the exact structure of the original naturally occurring substance. Since no methods of separating the original constituents of waxes are known at this time, the conventional procedure was used in this work. Thus our studies began with the saponification of the wax with alcoholic potassium hydroxide, removal of the alcohol and resolving of the whole into soap and non-soap portions. This separation was accomplished by the preferential solubility of the non-soap portion in Skelly-solve B and ethylene dichloride.

The isolation of unitary substances from natural fatty acids has been shown to be very difficult. Until about the last decade, the general method of separating fatty acids was based on fractional crystallization. The multiple crystallization method employed by deVisser, in 1898 (3), was shown to be incapable of yielding a pure compound (4,5).

Generally, the separation of homologs of fatty acids is best attained by fractional distillation of either their methyl or ethyl esters at low pressures through an efficient column (6). Longenecker (7) has prepared a review of the use of fatty acid ester distillation methods in fat analysis. He states that as early as 1877 Kraft (8) attempted the distillation of castor oil but succeeded only in cracking the oil. Bull (9) contributed materially to the problem of ester distillation in 1906. The introduction into the distillation system of vacuum pumps capable of continuously evacuating laboratory distillation apparatus to 1 mm. of mercury or less and the evolution of new types of fractional distillation equipment have caused a rapid

advance in ester distillation methods. Single turn glass helices (10) were shown to be particularly desirable for fatty acid ester distillations. Since 1934 Longenecker and others (11, 12, 13, 14, 15, 16) have used systems resulting from the development of theoretical knowledge of the fundamental principles involved in fractional distillations.

Schuette and Vogel (17) have shown that from the solidification points of a number of binary mixtures of saturated fatty acids of known composition one can plot a curve of solidification points against composition that is definite for every system of one acid and its second highest homolog. A naturally occurring odd-numbered fatty acid above pentanoic has never been found. If one has a mixture of maximum resolution and if the mean molecular weight and solidification point are known, it is possible to calculate the composition of this mixture by means of the above curve. Of course this calculation is only possible if it is certain that the mixture of maximum resolution is a binary mixture of two acids differing from each other by 2 carbon atoms.

In an investigation of the fatty acids of carnauba wax (18) we attempted to study the wax according to the following scheme:

1. Saponification of the crude wax.
2. Separation of the soaps from the non-soaps.
3. Preparation of the methyl esters from the acids obtained from the soaps.
4. Distillation of the crude methyl esters into distillable and non-distillable fractions.
5. Fractionation of the distillable portion into like-boiling fractions.
6. Division into 10-degree distilling fractions.
7. Division into 5-degree distilling fractions.
8. Saponification of the methyl esters into the corresponding acids.
9. Repeated recrystallization, followed by determinations of neutral equivalents and solidification points until definite results were obtained from Schuette and Vogel's curves.
10. Comparison of the mixed solidification points with samples of mixtures of pure synthetic acids.

Figure I shows the combination column and receiver used in the distillations. The packing in the column is a single turn glass helix. The column was heated with the type of heater used with a Widmer column. The distillate was collected in an 8-inch test-tube

and the opening closed with a rubber stopper. When fractions were cut, the vacuum was released up to the column, the rubber stopper removed, and the fraction replaced by a new tube and a fresh stopper inserted.

Figure II shows the special soda-lime, sulfuric acid, and freezing traps used.

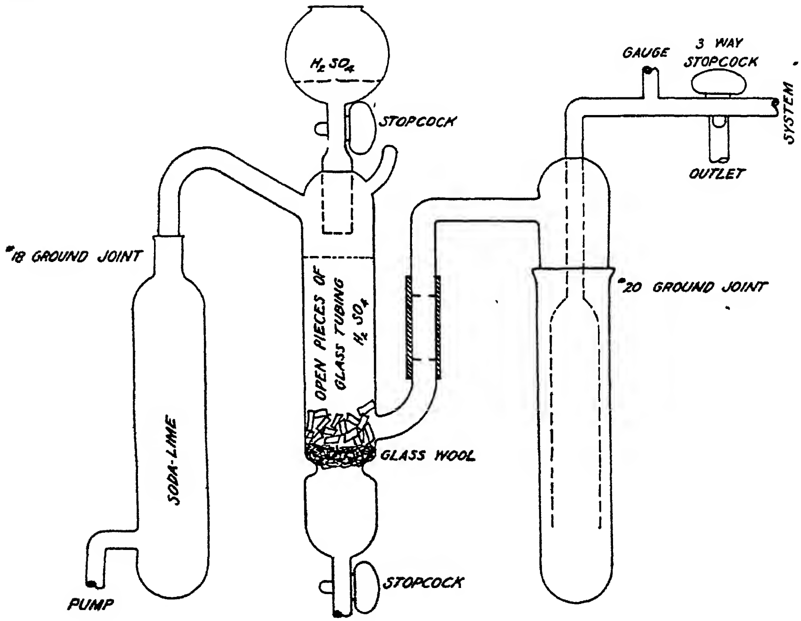

FIG. 1

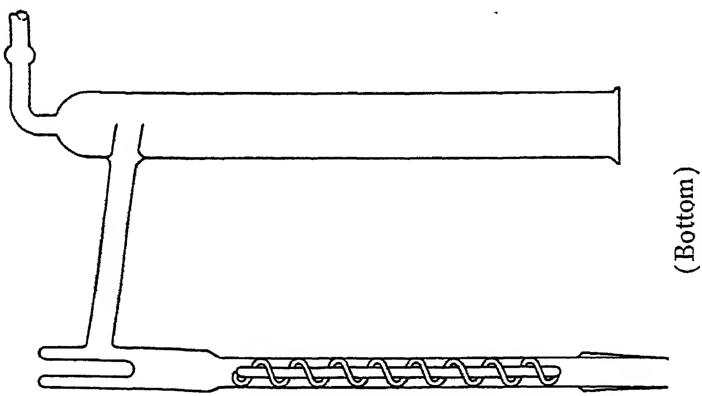

FIG. 2

The crude powdered wax (4150 grams) was saponified by refluxing with alcoholic potassium hydoxide for ten hours. After removal of the alcohol by vacuum distillation and subsequent drying in an oven, the dry cake of saponified wax was powdered and extracted with ethylene dichloride followed by Skelly-solve B. This extraction yielded the non-soaps as the soluble fraction and the soaps as the residue. The non-soaps consist chiefly of a mixture of high molecular monatomic aliphatic alcohols. This fraction was not studied in this investigation.

The soap fraction was converted to the free acids by agitation in ten per cent sulfuric acid at 85°C. Nine hundred grams of fatty acids melting at 68-72°C. were obtained. These acids were converted to their methyl esters by refluxing with absolute alcohol saturated with dry hydrogen chloride for 24 hours. After decolorizing the crude mixture with decolorizing charcoal and recrystallization from Skelly-solve B, there resulted 420 grams of methyl esters melting at 68-69° C.

These methyl esters were subjected to vacuum distillation through a short distilling head at temperatures from 150° to 350° C. at about a pressure of 0.03 mm. of mercury. A yield of 205 grams of distillate resulted. This distillable fraction was divided into five like-boiling portions to facilitate further fractionations. Each portion was then systematically distilled through the specially designed column shown in Figure I. Nine ten-degree distilling range fractions were obtained. Then, in turn, each of these fractions was further subdivided into five-degree distilling range fractions. Table IV is a tabulation of the data connected with this final fractionation.

TABLE IV.—Constants of Refractionated Distillates of Five-Degree Fractions.

Fraction	Wt. in Gm.	M.Pt., Degrees	S.Pt., Degrees	R.Pt., Degrees	B.Pt.Range, Degrees	Av.Pressure, Mm.
1	2.51	27.4	27.30	27.7	105-115	0.012
2	6.40	40.2	40.10	39.8	115-120	0.02
3	9.24	42.2	42.70	42.1	120-125	0.02
4	2.14	44.9	44.82	45.0	130-135	0 02
5	6 73	50.0	49.96	49.8	140-145	0.025
6	9.01	50.7	51.69	51.1	145-150	0.025
7	69.70	54.4	56.20	54.4	150-155	0.03
8	5.15	57.1	58.16	57.3	160-165	0.04
9	1.48	58.6	58.28	58.9	170-175	0.035
10	16.71	61.4	62.63	62.2	185-190	0.04
11	28.21	63.0	65.17	64.0	Over 190	0.04

The fatty acids were recovered from their methyl esters in the same manner as the crude acids were obtained from the original Carnauba wax. Table V is a tabulation of the physical constants of the fatty acids obtained from the corresponding fractions of methyl esters as shown in Table IV.

TABLE V.—Physical Constants of Fatty Acids Obtained from Methyl Ester Fractions.

Fraction	Wt. in Gm.	M Pt., Degrees	S.Pt., Degrees	R.Pt., Degrees	Mol. Wt.
1	1.60	60.2	60.78	60.2	294
2	3.75	69.0	69.32	69.2	291
3	6.76	71.4	71.46	71.4	298
4	1.11	66.1	68.01	67.0	320
5	5.36	72 8	74.51	73.7	330
6	5.51	71.3	71.46	71.2	338
7	58.70	78.6	78.78	78.2	349
8	3 45	76.1	77.51	77.2	375
9	0 84	77.4	77.18	77.9	388
10	11 86	80.2	80.92	79 4	399
11	24.95	84.0	85.62	84.6	424

After application of the above data to the proper binary mixture curves of Schuette and Vogel, it was seen that the fractions were not binary mixtures. Therefore recrystallization was next resorted to. Each fraction was recrystallized systematically over and over until finally a set of fractions were obtained whose data gave consistent results when applied to the proper Schuette-Vogel curves. This data is summarized in Table VI. Fraction 1 of Table V became so small it was finally set aside. Fraction 2a in Table VI represents a resolvement of fraction 2 in Table V.

TABLE VI.—Composition of Acid Fractions.

Fraction	Composition
2a	31.5 mol per cent C_{18}; 68.5 mol per cent C_{20}
2 and 3	3.0 mol per cent C_{18}; 97.0 mol per cent C_{20}
4	75.0 mol per cent C_{20}; 25.0 mol per cent C_{20}
5	86.7 mol per cent C_{22}; 13.3 mol per cent C_{24}
6	67.0 mol per cent C_{22}; 33.0 mol per cent C_{24}
7	14 5 mol per cent C_{22}; 85.5 mol per cent C_{24}
8 and 9	44.0 mol per cent C_{24}; 56.0 mol per cent C_{26}
10	Definitely C_{26} and C_{28} present
11	Definitely C_{26} and C_{28} present and possibly C_{30}

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A Malformed Skull of *Aplodinotus grunniens* Rafinesque

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Abstract: A malformed skull of *Aplodinotus grunniens* Rafinesque is described, and the mechanics of the adjustments to the resulting abnormal conditions are discussed.

Introduction

While making a study of the skull of the fresh water "Drumfish" or "Croaker", *Aplodinotus grunniens* Rafinesque at the Museum of Vertebrate Paleontology, University of Kansas during 1940, the writer came upon a specimen in which the occipital region around the foramen magnum and the first vertebra had been distorted. This specimen was the larger one of two which were used at the beginning of the project. At that time, it was the intention of the writer to dismantle the smaller skull for morphological study and to preserve the larger specimen for drawings. As a result, the discovery of the malformation of the larger specimen was not made until the first skull had been disarticulated and work was already under way on the first project. A number of new specimens were obtained for further study. Although the soft anatomy of the malformed specimen was not seen, the conclusion that it is a sexually mature individual is based on a comparison with fresh specimens of equal size which were sexually mature and which when later skeletonized by the dermestid method showed a similar stage of development in the bony structure of the skeleton.

Description.—The malformed specimen appeared normal externally. No evidence of the internal condition was discernable until the scales which remained on the specimen after skeletonization were removed.

From the posterior aspect of the skull the displacement of the occipital region is prominent. Using the supraoccipital as a medium line of the skull, it is evident that the basioccipital is totally displaced from the center toward the left while the right edge of the centrum surface of the basioccipital is in line with the crest of the supraoccipital. The centrum surface of the basioccipital is not excavate as in normal specimens, but is flat save for several small

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*Through the courtesy of Dr. Claude W. Hibbard, Curator of the Museum of Vertebrate Paleontology, University of Kansas, I have been accorded the privilege of writing upon a specimen observed in a previous study.

tubercles. The dorsal border, instead of being rounded, has a very shallow "U" shape, the left exoccipital fitting into the "U". The right exoccipital only contacts the basioccipital at the extreme dorso-lateral edge. There is a slight indication of ankylosis between the centrum surface of the basioccipital and the left exoccipital at the point of contact. The upper portions of the exoccipitals which enclose the ventral portion of the supraoccipital maintain their normal positions. However, the posterior border of the right exoccipital where it joins the supraoccipital is double the thickness of the left.

The ventral surface of the basioccipital is only slightly misshapen. From the ventral aspect, it can be seen that the centrum surface has been pushed anteriorly on the right side. At the same time, the lateral surface of the right exoccipital and its neighboring bones has been moved posteriorly. The right side of the parasphenoid has shifted slightly to the left and the right alisphenoid has shifted slightly to the rear in relation to the left alisphenoid. The anterior end of the parasphenoid shows no sign of any movement. From the dorsal aspect of the skull, no indication of distortion can be seen. The movement has altered but slightly the shape of the foramen magnum, and only a slight shift toward the left is noticeable.

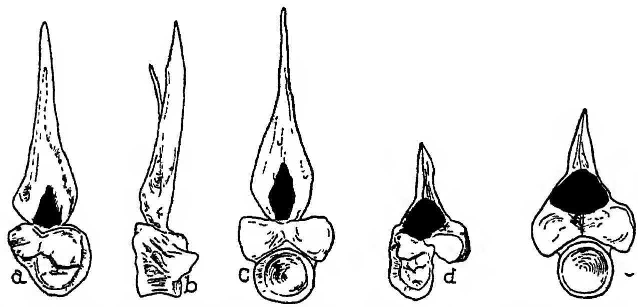

FIG. 1. *Aplodinotus grunniens* Rafinesque. (a) Anterior view of the first vertebrae of the abnormal specimen. (b) Lateral view of the left side of Fig. 1a. (c) Anterior view of the first vertebrae of a normal specimen. (d) Posterior view of the occipital region of the abnormal specimen. (e) Posterior view of the occipital region of a normal specimen.

The first vertebra has undergone changes in accordance with the changes of the skull proper, or the converse. From an anterior view, the centrum is not circular, but its shape conforms to the basioccipital and the exoccipital with which it joins. Anteriorly the centrum is not excavate. The left "pre-zygapophysis" has been crushed downward into the concavity of the centrum. The right "pre-zygapophysis" retains its normal position but has been encroached upon along its mesial border by the left "pre-zygapophysis". The neural spine

is but slightly distorted from all aspects except from a lateral view. The anterior portion of the neural spine is split where the muscles exerted undue pull on the spinous attachment.

In summary, it may be said that the left side of the basioccipital region has been forced to the left and downward, with a corresponding movement of the first vertebra. The writer has only the first three vertebrae at his disposal, but placing these in their proper fixed position, it can be seen that the spinous processes lean toward the right, in opposition to the leftward movement of the posterior end of the skull.

Conclusion: The skeletal movement was presumably caused by an injury between the first vertebra and its attachment to the skull. This injury caused either the vertebrae to move first, the basioccipital region moving in order to compensate for it, or the converse, the movement of the veterbrate to the right. Whether this movement was caused by a muscular compensation cannot actually be determined. Here, the question arises as to whether or not the injury pertained to the musculature in the first place. It is possible that the movement of the musculature was the first involvement and the skeletal movement was secondary, or the converse if the musculature was involved.

I am inclined to believe that the injury was primarily skeletal, the musculature then becoming involved and playing a part in the compensation. The question of whether the lack of a concavity in the centrum of the basioccipital and the first vertebra was due to a crushing effect, growth, or both must also be considered.

This individual received in its youth an injury which likely would have been fatal to a higher animal, (that is, "breaking its neck"). It was able to make a morphological compensation which enabled it to reach adulthood. The adjustment made was not an easy one, but may be thought of as almost perfect. Whether such incidents in the life of fishes are common is doubtful, but it indicates the extent of damage that can be done without fatality.

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A Simplified Percentage Table of Whole Numbers 1-100

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In some lines of biological investigation where analysis and study of variables require the figuring of a great number of percentages there has long been a need for a simple table from which percentages of from 1 to 100 items can be found at a glance. So far as known no such table is already available. Most tables cover many pages and show percentages computed to 3 or more places. The simplified table, which follows, is ideal for many purposes. It was developed from one prepared by Dr. R. H. Painter of Kansas State College and used for many years to rate hessian fly infestations. It has been a very convenient time saver, and workers who have had an opportunity to use it have urged that it be made available in printed form.

In using the table the divisor, i.e., the total number of objects, is located in the first vertical column and the dividend in the nearest horizontal column in bold face type. The quotient is found at the corresponding intersection of the two columns. Thus, if 19 of 63 plants are infested in a certain experiment, the percentage of infestation can be found by locating 63 in the first vertical column and then following the horizontal column across to the bold face 19. The number on line 63 directly beneath 19 is the percentage of plants infested. In this case the number is 30, or 30% of the plants were infested.*

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*The illustration given on the following page shows the manner of constructing the table. A much larger table, measuring 12 x 14 inches, has been published for investigators who have more extensive need for such a device. Copies of the large table on good quality paper can be secured from the managing editor of the *Transactions*, Dr. W. J. Baumgartner, Snow Hall, University of Kansas, Lawrence, for 15 cents each, postage paid. —The Editor.

[illegible]

The Allylation of Cyclohexanone

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Introduction

Application of the principles of the modern electronic theory to organic chemistry has proved fruitful, not only in correlating facts and in predicting new reactions, but also in specifying the most favorable experimental conditions for conducting known reactions.

During the course of our syntheses of certain polynuclear aromatic hydrocarbons, large amounts of an important intermediate, monoallylcyclohexanone, were required. Monoallylcyclohexanone may be prepared directly from cyclohexanone by allylation of the ketone with either allyl bromide or allyl iodide in the presence of the basic condensing agent sodamide.

This reaction was rather thoroughly studied by Cornubert,[1] who ran experiments on the allylation of cyclohexanone using allyl chloride, allyl bromide, and allyl iodide. Inasmuch as the best yield of pure monoallylcyclohexanone reported by the French investigator was only 5.6% based on cyclohexanone used, a re-investigation of the reaction in the light of modern electronic theory was undertaken.

Discussion

In his preparation of monoallylcyclohexanone Cornubert followed the standard procedure for the alkylation of ketones in general.[2]

Molar quantities of sodamide and cyclohexanone were mixed by stirring during the dropwise addition of the ketone to a suspension of the sodamide in absolute ether. After all the cyclohexanone had been added, the mixture was refluxed for two hours to remove the ammonia, and a molar quantity of the allyl halide was introduced dropwise under reflux.

Under these conditions, the low yield (5.6%) of monoallylcyclohexanone was attributable to the further allylation of that product to di-, tri-, and tetra-allylcyclohexanones, and to the formation of appreciable amounts of other high boiling materials pre-

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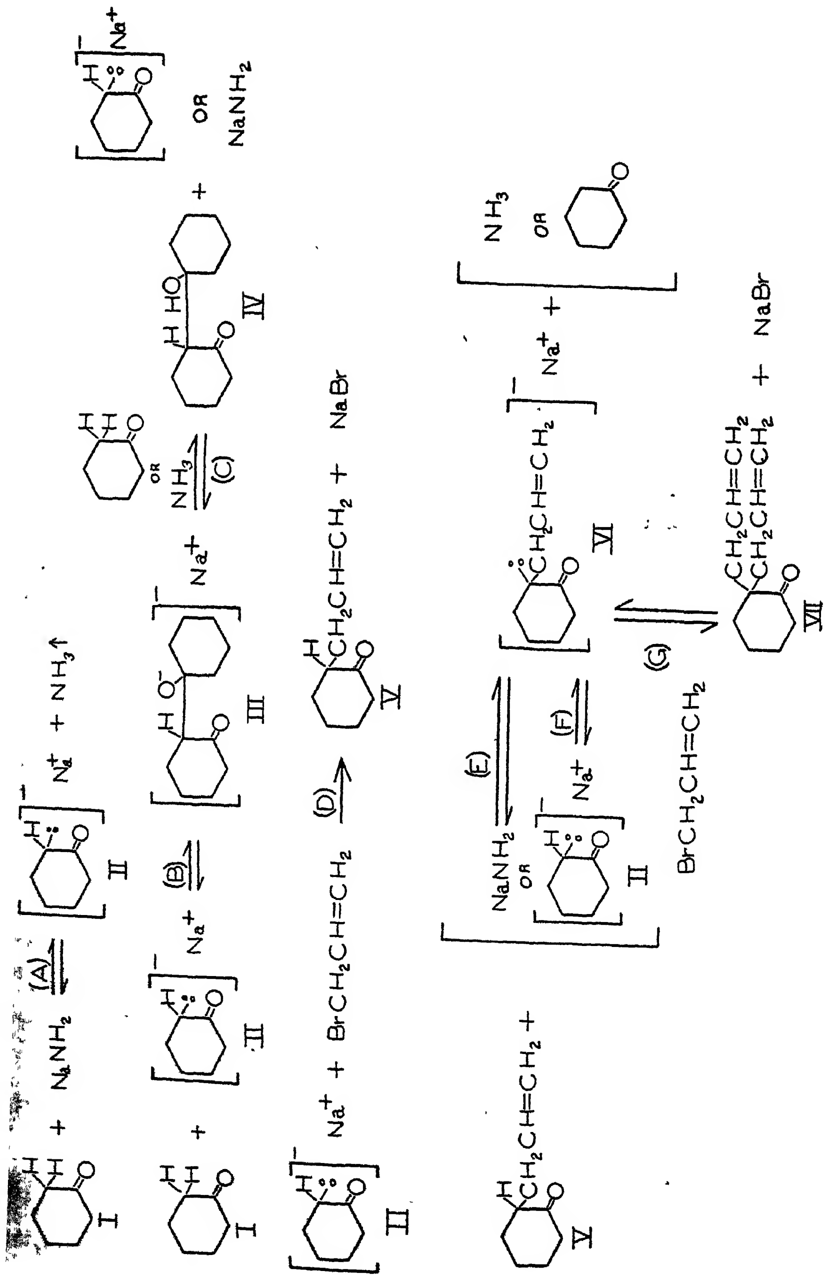
[1]Cornubert, Ann. chim., *16,* 145 (1921).

[2]See, for example, Nasarow, Ber., *70,* 594 (1937); Haller and Cornubert, Bull. soc, chim., *39,* 1724 (1926); *ibid., 41,* 367 (1927).



sumably arising from the self-condensation of cyclohexanone. By more efficient fractional distillation of the products, the present authors were able to raise the yield of monoallylcyclohexanone following the exact procedure of Cornubert, but only to a maximum of 21% based on cyclohexanone used.

The important equilibria involved in the synthesis are represented by the following equations:

In the first step, (A), the carbanion, II, of cyclohexanone is formed upon the removal of a proton from the weak acid cyclohexanone, I, by the strong base the amide ion. Step (B) represents the attack of the nucleophilic cyclohexanone carbanion at the electrophilic carbonyl carbon of an unreacted cyclohexanone molecule to give the complex alkoxide ion III. The latter may then accept a proton from ammonia or another unreacted cyclohexanone molecule in reaction (C) to form the aldol-type condensation product of cyclohexanone, 2—(1—hydroxycyclohexyl)—cyclohexanone, IV.

Equation (D) shows the condensation of the cyclohexanone carbanion, II, with allyl bromide to give the desired product monoallylcyclohexanone, V.

Further reactions are possible, however, as the latter compound is an acid and may donate a proton to either of the strong bases, the amide ion or the carbanion of cyclohexanone, to form the carbanion of monoallylcyclohexanone, VI, as represented in steps (E) and (F). Condensation of the carbanion, VI, with allyl bromide in reaction (G) results in the formation of unsymmetrical diallylcyclohexanone, VII.

It is at once apparent that the synthesis of monoallylcyclohexanone proceeds in two steps (A) and (D), and that reactions (B), (C), (E), (F), and (G) are to be avoided. Reasoning from the law of LeChatalier, one may specify those experimental conditions which favor the desired reactions and hinder those which lead to the formation of side-products.

Desired reaction (A) is favored by the immediate removal of free ammonia as it is formed, whereas the undesired reactions (B) and (C) are hindered if the presence of an excess of either cyclohexanone or ammonia is avoided. These conditions may be realized experimentally by the slow addition of cyclohexanone to a suspension of sodamide in absolute ether under reflux while dry nitrogen gas is bubbled into the ether to decrease the solubility of ammonia in the mixture.

Continued refluxing after the addition of the cyclohexanone is completed should serve to remove all of the ammonia and to drive reaction (A) nearly to completion. Furthermore, it is highly important that no unreacted sodamide remain after the addition of allyl bromide to participate in the undesired reaction (E).

Careful study of reactions (D) and (F) reveals that the carbanion of cyclohexanone enters into both the desired and undesired reactions. Competition for the carbanion of cyclohexanone occurs between allyl bromide and monoallylcyclohexanone, the former serving to bring about the desired condensation, (D), the latter, the undesired protolysis, (F). Increase in the ratio of allyl bromide to monoallylcyclohexanone favors reaction (D). One may meet this condition by placing all of the allyl bromide in the reaction vessel at the outset of the second reaction rather than by adding it slowly as is usually done.

Inasmuch as the reaction of allyl bromide with cyclohexanone, reaction (D), proceeds at a much more rapid rate than the self-condensation of cyclohexanone, reactions (B) and (C), excess cyclohexanone added along with allyl bromide in the second step of the synthesis serves to reverse the undesired reaction (F) without leading to the formation of appreciable amounts of 2—(1—hydroxy-cyclohexyl)—cyclohexanone, IV.

In the present investigation, modification of the experimental conditions employed by Cornubert[1] to satisfy all of the optimum conditions discussed above led to the facile production of monoallyl-cyclohexanone in yields of 53-56% and rendered the reaction suitable for the large-scale synthesis of the product. The marked success achieved in enhancing the yield of this important intermediate by the employing of the most favorable experimental conditions as dictated by theoretical considerations suggests that it might prove fruitful to re-investigate many similar condensation reactions in the light of modern theoretical principles. Further studies of this type are being conducted in this laboratory.

Experimental

Synthesis of Monoallylcyclohexanone According to Cornubert—Exactly 294 g. (3 moles) of cyclohexanone was added dropwise with stirring under a nitrogen atmosphere to a suspension of 120 g. (3 moles) of sodamide[3] in 900 cc. of absolute ether contained in a 3-liter-3-necked round bottom flask equipped with mercury-seal stirrer,

[3]Freshly prepared in 10 mole quantities according to Nieuwland, J. Am. Chem. Soc., 56, 2120 (1934).

condenser, and nitrogen-inlet tube. After the addition of the cyclohexanone was completed (2 hours), stirring was continued under reflux for 3 hours while ammonia gas was boiled off. Absolute ether was added occasionally to keep the total volume constant.

To the refluxing mixture there was then added dropwise with stirring a solution of 363 g. (3 moles) of allyl bromide in 700 cc. of absolute ether. The mixture was refluxed for 3 hours after all of the allyl bromide had been added.

Water just sufficient to dissolve the sodium bromide was added to the mixture, the ether layer was separated, the water layer extracted twice with 200 cc. portions of ether, and the combined ether solutions were dried over anhydrous sodium sulfate. Following removal of the solvent with a take-off condenser, the residue was distilled fractionally through a 36″ column, packed with ¼″ Berl saddles, and equipped with a total reflux partial take-off head, to yield 53 g. of recovered cyclohexanone and 72 g. (21% based on cyclohexanone used) of pure monoallylcyclohexanone; b.p. 71.0-71.6° at 5 mm. pressure, $n^{24}D$ 1.4676, m.p. oxime 71.3-72.1° (corr.). The higher boiling residue was not further fractionated.

Improved Synthesis of Monoallylcyclohexanone—In a typical run, 294 g. (3 moles) of cyclohexanone was added in slow drops with stirring under reflux to a suspension of 120 g. (3 moles) of sodamide in 900 cc. of absolute ether contained in a 3-liter-3-necked flask. Nitrogen gas was introduced continuously by means of an inlet tube leading below the surface of the liquid. After all the cyclohexanone had been added, refluxing was continued until evolution of ammonia gas had ceased (3½-4½ hours). Absolute ether was added from time to time to keep the total volume of material constant.

The mixture was then cooled by means of an ice-bath and a solution of 363 g. (3 moles) of allyl bromide and 196 g. (2 moles) of cyclohexanone in 700 cc. of absolute ether was added at once. Upon removal of the ice-bath, the condensation proceeded with vigorous refluxing which was controlled by further use of the ice-bath. After the reaction had subsided, the mixture was refluxed for 3 hours on a steam bath.

Water was then added dropwise until all of the sodium bromide had dissolved. The ether layer was separated and the water layer extracted twice with 200 cc. portions of ether. After the combined ether extracts had been dried over anhydrous sodium sulfate, the solvent was removed with a take-off condenser. Fractional distilla-

tion of the residue gave 243 g. of recovered cyclohexanone and 195 g. (55% based on cyclohexanone used) of pure monoallylcyclohexanone; b. p. 71.0-71.5° at 5 mm. pressure.

Summary

1. Factors affecting the equilibrium reactions involved in the allylation of cyclohexanone by condensation with allyl bromide in the presence of the basic condensing agent sodamide are discussed from a theoretical standpoint. Optimum experimental conditions for the synthesis of monoallylcyclohexanone are postulated.

2. The allylation of cyclohexanone under optimum conditions for the synthesis of monoallylcyclohexanone as predicted on a theoretical basis has made possible an increase in the yield of that product from 5.6%, as previously reported, to 53-56%.

3. The results reported in the allylation of cyclohexanone under modified experimental conditions are of interest because they demonstrate the utility of the application of theoretical principles to the actual control of an organic synthesis in favoring a desired reaction and in the elimination of side reactions. Likewise, they suggest that similar syntheses might be improved by careful study and control of experimental conditions.

Some Experiments With Vitamin C and Its Effect on the Blood of Guinea Pigs

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Introduction and Review of Literature

Previous experiments performed on tissues chiefly of mesenchymous origin—such as teeth, bone, tendon, and muscle, showed definite histological and cytological changes, so this experiment was started to see whether the blood, likewise mesodermal in origin, would undergo any similar variation.

Harman and Traulsen (1943) studied the effect of Vitamin C-deficiency upon skeletal muscle. At the same time, Ascham and Geddes(unpublished) studied the ascorbic acid content in the blood stream of these animals at the various stages of scurvy. Blood samples were taken on approximately every seventh day and the amount of ascorbic acid present was calculated. This experiment revealed little difference between the Vitamin C content in the blood stream of normal animals and that of experimental animals. In this experiment, as in preceding ones, the experimental guinea pigs in comparison to normals have very little blood during the later stages of scurvy.

Considerable work had been done previously concerning the effect of Vitamin C-deficiency on blood with respect to erythrocyte and leucocyte counts, and hemoglobin content; but little work had been done regarding any histological or cytological changes.

This problem was to include red and white corpuscle counts and hemoglobin index.

According to Sigal (1939) there is a general agreement that Vitamin C-deficiency causes a decrease in the erythrocyte counts. Some of these who found decreases were Wales [quoted by Jackson and Harley (1900)], Findlay (1921), Gasperi (1926), Meyers and McCormick (1928), and Mether, Minot, and Townsend (1930).

Sigal (1939) states that during the first ten days of deletion, there occurred only a slight decrease in erythrocytes and hemoglobin, but during the deletion period from ten to twenty days; anemia had become severe and was accompanied by a decrease in leucocytes and hemoglobin.

Browning (1931) said there appeared to be a discrepancy in the red blood cell counts according to different observers; but that the opinion of the majority is that alterations, if any, are slight and transient. Likewise, Wasserman (1918) found the condition variable with the red blood cell count at times abnormally low (2,000,000 per c.m.m.) and at other times; especially during convalescence, raised as high as 7,000,000 per c.m.m.

Hess and Fish (1914) and Brandt (1919) reported very little decrease in the number of red corpuscles in human scurvy. Hryniewicz and Lawrynowicz (1927) likewise found no appreciable change in red corpuscles nor any appreciable diminution in hemoglobin content.

The change in leucocytes has been found to be slight and variable. Laboulbene (1900) found an increase in white corpuscles in human scurvy and Wasserman (1918) observed sometimes a relative, sometimes an absolute increase in the number of lymphocytes, with an increase of eosinophil cells. A slight increase in small lymphocytes has been reported by most workers, including DeMare and Brancato (1929) and Gasperi (1926). The leucocytes have been found below normal by Werkman and coworkers (1923), DeMare and Brancato (1929), and Gasperi (1926), and above normal by Meyer and McCormick (1928). Findley (1921) however, has suggested that the absolute increase in polymorphonuclear leucocytes noted by Meyer and McCormick may possibly have been due to a bacterial infection superimposed upon the vitamin deficient animals.

Randoin and Michaux (1929) considered that the hemorrhagic lesions associated with scurvy are due not only to the increased permeability of the capillaries but to an increasing dilution of the blood. They showed that in guinea pigs on a synthetic vitamin C-free diet, the water content of the blood remained normal during the first three weeks, and then began to rise rapidly from 80% to 91% up to the time of the death of the animal (28 to 32 days).

Experiment

Four series of animals were started at various intervals through out the year. The first series was composed of twenty-four animals and was placed on Sherman's Vitamin C-free diet, June 14th. They were given ascorbic acid tablets according to body weight, (.66 mg per 100 grams of weight). These animals soon became ill and within two weeks, half of the animals were dead, so this series was discontinued.

On July 8, a second series of animals was obtained. This consisted of fifteen middle-aged guinea pigs, ranging in weight from 275 grams to 600 grams and four older ones weighing from 750 grams to 1000 grams. All were fed a normal diet consisting of guinea pig pellets and additional greens in the form of lettuce and spinach until they became accustomed to their environment.

On July 22, they were divided into two lots and all were fed the Sherman, LaMer, and Campbell (1922) Vitamin C-free diet. One lot was composed of seven medium sized animals and two large animals designated as controls. The regular diet of the controls was supplemented daily by vitamin C in the form of Cebione to the amount of .66 mg per 100 grams of body weight. (This has been calculated to be a sufficient amount for the maintenance of the guinea pig body.) The second lot composed of eight medium sized animals and two large animals was designated as experimentals and were deprived of Vitamin C after this date.

Erythrocyte counts, leucocyte counts, and hemoglobin measurements were made on the experimental animals approximately every third day. The same counts and measurements were made on the controls once a week.

The white blood cell counts were taken by means of a Thoma pipette, hydrochloric acid (N/10), and a haemacytometer. The red cells were counted by use of a Thoma pipette, Hayem's solution, and a haemocytometer. The hemoglobin index was measured by means of the white cell solution in the Haden Hausser haemoglobinometer. The other two series started contracted a blood disease and were discontinued shortly after the beginning of the experiment.

Results

As previously mentioned, infection in the colony complicated the experiments, so the original problem has not been completed, but the data obtained justify certain conclusions.

When the counts had been made and tabulated, it was noticed that Vitamin C-deficiency generally causes a decrease in erythrocytes, although there was a matter of individual difference. The general trend was downward in the deficient animals for nine out of ten animals had curves of descending nature following the removal of Vitamin C from the diet. Five control animals had curves with an upward trend, three had a slightly downward trend and one remained the same. Two of the three animals (12 and 13) that had curves of the descending nature, died with the bacterial infection.

Probably the most noticeable result was the decrease in hemoglobin, for as soon as Vitamin C was removed from the diet, there was a definite downfall in hemoglobin, falling as much as 30% in some cases. Nine deficient animals, at the close of the experiment, had lower hemoglobin readings while the tenth remained about the same. In comparison, six normal guinea pigs had hemoglobin readings that were slightly higher than the original readings, one had the same reading, and the other two had a drop in hemoglobin percentage; however, one of these two animals (13) was infected, so died early.

The leucocyte counts were variable, for some animals upon the Vitamin C-deficient diet reacted one way and others reacted reversely. Seven out of ten animals showed the leucocyte counts to be below normal when Vitamin C was removed from their diet; but two had higher counts, and the other remained about the same. In comparison to the normals, four had higher counts, four had slightly lower counts, and the other remained the same.

During this experiment, as in preceding ones, there was a definite circulatory change, whether it was a hydremic effect cannot be said because no measurements were taken; but as the deficiency increased, there appeared a circulatory change. The first time blood was taken from the animal, it could be taken with ease from any peripheal vessel of the ear; but as the experiment continued, blood in some cases could not be obtained from the marginal vessels, but had to be taken from a portion of the body nearer the heart.

Whether the change was due to a collapse of peripheal blood vessels, a decrease in the volume of the blood, or a shift of the blood content from the peripheal portions to the central, more vital portions, is not known. It is merely known that a definite circulatory change occurs.

The animals were all apparently normal in the four series until the regular Sherman, LeMer, and Campbell (1922) diet was introduced. In all four series shortly after this feed was introduced and ascorbic acid was being administered in the form of "Cebione," abnormalities and diseased animals soon resulted.

When the animals in series two appeared abnormal and started dying, numbers 13 and 14 were posted. Post mortem examination revealed multiple foci of abscesses scattered throughout the mesenteries, spleen, pancreas, and intestine which is an indication of the presence of a generalized septecemia. Pneumonia was suspected, so the lungs were examined but they were of a normal consistency,

texture, and color and there was no evidence of consolidation, hepatization, or edematous swellings which would have indicated a pneumatic condition. Therefore, the early death of these animals was not due primarily to the deficiency of Vitamin C, but from the secondary factors involved.

Paralleling the Vitamin C-deficiency, there was a lowered resistance of the animal's body and a generalized metabolic reduction which made the animals susceptible to a secondary invasion—bacteria.

From research and laboratory experience, it is known that the body is a constant reservoir for bacteria at all times. In a state of health these bacteria remain dormant, but as in a vitamin deficiency, these bacteria took up an active state and the animals became diseased.

After four successive experiments, it was concluded that the diet composed of substitutes did not contain quite the food value that the original diet of pellets and substitutes of greens as alfalfa or lettuce.

Discussion

The results derived from this experiment closely coincide with previous studies reported. Like Mether and coworkers (1930) or Gasperi (1926) or Findlay (1921), we found that Vitamin C deficiency generally causes a decrease in erythrocytes. With respect to the leucocytes, the assumption that the effect produced by the deficiency seemed to be more or less a matter of individual difference, the conclusion was similar to Werkman and coworkers (1923) DeMare and Brancato (1929) or Gasperi (1926) who found leucocyte counts to be below normal when Vitamin C was removed from their diet; but like Meyer and McCormick, two of the experimentals showed a slight increase. This work, too, was in close agreement with Sigal (1939) who found that during the first ten days there occurred only a slight decrease in erythrocytes and hemoglobin; but that during the deletion period from 10 to 21 days, anemia had become severe and this was generally accompanied by a decrease in leucocytes and hemoglobin.

Randoin and Michaux (1929) also noted the circulatory change and suggested the hemorrhagic lesions associated with scurvy were due not only to increased permeability of the capillaries, but to an increasing dilution of the blood.

Conclusions

1. There was a matter of individual difference as to whether

there was an increase or decrease in the erythrocyte counts during the life of the animal, but the general trend was downward in the deficient animals.

2. Vitamin C-deficiency generally caused a decrease in hemoglobin.

3. There is a tendency for the vitamin C-deficient animals to have a decreased leucocyte count; however, this difference was not constant and the difference between the experimental and the controls was not great.

4. Following the onset of scurvy, there occurred a circulatory change of some nature.

5. The experimental substitute foods used apparently did not contain all of the food value of grains and fresh greens.

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A Note on the Mortality of Snakes on Highways in Western Kansas

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The death toll of snakes taken by automobiles on our highways every year must be tremendous. Few data have been previously available. For this reason the following account of a short trip by car on May 29, 1943, in western Kansas should be of interest. A total of 260 miles was covered; partly over asphalt and partly over gravel highways. A count of dead snakes was kept, the following table enumerating the species noted.

TABLE I
Species of snakes found dead on the highway.

Species	No.	%
Spotted King Snake	2	4
Bull Snake	31	54
Milk Snake	1	2
Banded King Snake	1	2
Blue Racer	3	5
Whip Snake	3	5
Miter Snake	1	2
Hognose Snake	1	2
Unidentified	14	24
Total	57	100
No. on gravel	11	19
No. on asphalt	46	81

As the table shows, a total of 57 dead snakes was counted. This number averages one snake for every 4.5 miles traveled. Of the 57 only 11 were counted on the gravel while 46, or 81 per cent of the total, were found on the asphalt. The much greater number on the asphalt may be due to several factors of which one is probably the heavier traffic and the fact that the asphalt warms up during the day and retains heat better than gravel.

The slow, harmless bull snake, that helps to hold in check small rodents on the prairie, made up 54 per cent of all the specimens counted. If, throughout its entire range, the bull snake is slaughtered by cars in the same proportion, some idea of the tremendous death rate can be judged. It should be noted that the trip on which this

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count was made occured during a period when highway traffic was 30-50 per cent less than in pre-war years.

Very few dead snakes occured on the highway when it passed between fields under cultivation (winter wheat, canes, etc.) The majority of the dead snakes were counted on the highway between pastures and other uncultivated areas. Many dead snakes were probably missed, especially those that may have been thrown aside or managed to crawl off onto the grass covered shoulder or into the ditch. Such slaughter seems tragic when it is well known that most species of snakes are harmless and help to keep down the rodent and insect populations that would otherwise destroy valuable crops.

The Stability of Vitamin A in An Experimental Poultry Feed

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Vitamin A is a necessary food factor for the growth and general development of many animals. The vitamin is essential, among other things, for the proper functioning of epithelial tissues. It is found in the pigment of the retina, and if not present in sufficient quantities, poor vision results. Because of its importance in animal nutrition, it is essential that adequate vitamin A be incorporated in animal feeds.

An experimental feed consisting of carotenoid-free ingredients has been used at this experiment station for studies in poultry nutrition. This feed has the following composition: White rice, 67%, dried skim milk, 11%; dried yeast, 5%; bagasse, 4%; calcium carbonate, 2%; and alcohol-extracted meat and bone scrap, 11%. The extraction of the meat and bone scrap removes the fat-soluble vitamins and pigments. To the above mixed feed is added about 4500 I.U. of vitamin A per pound.

Earlier experiments with this ration, using cod liver oil as a source of the vitamin A, showed that the vitamin A potency was being lost very rapidly. This loss was not surprising since the vitamin is unstable, especially in feed mixtures. where it is constantly exposed to the action of air and minerals. Further, the extraction process removes the naturally-occurring oil-soluble antioxidants normally present in the meat and bone scrap, and possibly forms small amounts of peroxides or other substances destructive to vitamin A. It was decided to attempt the preparation of a carotenoid-free feed which would retain vitamin A for a greater length of time, and to determine whether a relatively simple physico-chemical method could be used to estimate the vitamin A potency of this type of feed.

Procedure

The stability of vitamin A in the carotenoid-free feed was tested using both cod liver oil and an emulsion of fish liver oil in molasses†

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†A commercial product, Exadol-M, supplied by Squibb and Sons.

as the sources of vitamin A. The feed samples were prepared by adding quantities of cod liver oil or the oil-molasses emulsion estimated to contain 10,000 I.U. of vitamin A to one pound batches of the mixed feed. Due to the viscous nature of molasses, special care had to be exercised to obtain a homogenous mixture of the molasses emulsion with the feed. Satisfactory dispersion was effected by grinding the feed containing the molasses emulsion in a Wiley mill. However, the mill either mechanically retained or in the grinding process destroyed some of the vitamin. The mixing of the cod liver oil with the feed offered no special difficulties. The samples were analyzed immediately after mixing and at intervals for a period of eight weeks.

Method of Analysis

Extract a twenty-gram sample of feed in a Waring Blendor‡ with 100 ml. of peroxide-free ether. Repeat twice using only 50 ml. portions of ether. A total extraction time of six minutes is sufficient. Following each extraction, filter the ether solutions using a Buchner funnel. Combine the ether extracts and transfer to a round-bottom boiling flask. Add 25 ml. of aldehyde-free methanol and a few glass beads to prevent bumping. Evaporate the ether from the mixture using reduced pressure and a water bath below 70° C. for heating. Add 2 ml. of saturated aqueous potassium hydroxide to the methanol solution, and saponify by refluxing the mixture for ten minutes. Add 40 ml. of distilled water, cool the flask, and transfer contents of the flask to a 500 ml. separatory funnel, rinsing the flask with an additional 40 ml. of water. Add 100 ml. of ether and extract the vitamin A by gentle shaking of the separatory funnel. Re-extract the water-methanol layer twice using 50 ml. portions of ether. Emulsions which may form during this extraction may sometimes be broken by the addition of a very small amount of methanol. Combine the ether extracts in a separatory funnel and wash 5 times with 50 ml. of cold distilled water. The last wash water should test free of alkali. Dry the ether in the separatory funnel by shaking with about 10 grams of anhydrous sodium sulfate. Pour the dried extract from the top of the separatory funnel, through a filter paper containing a small quantity of anhydrous sodium sulfate, into a volumetric flask. Rinse the sodium sulfate with small portions of ether, using the rinsings to make the volume to 200 ml. Part of this procedure has been described previously.[1]

‡Caution—The Waring Blendor sparks at the brushes. A Soxhlet extractor is sometimes used for this extraction, but requires much more time for the analysis.

Evaporate an aliquot of the ether extract under vacuum in an all-glass apparatus, heating by use of a water bath below 70° C. Cool the evaporation flask and add 5 ml. of U.S.P. chloroform as the vacuum is released. Transfer the solution to a small graduated cylinder and make up to a volume of 10 ml. with chloroform rinsings from the evaporation flask. The chloroform solution must be clear, indicating it is free of moisture. If moisture remains at this point, it sometimes may be removed by re-evaporation of the chloroform solution.

All-glass apparatus constructed with ground-glass joints is recommended for use in all these operations. Since light destroys vitamin A, protection from strong light is necessary.[2]

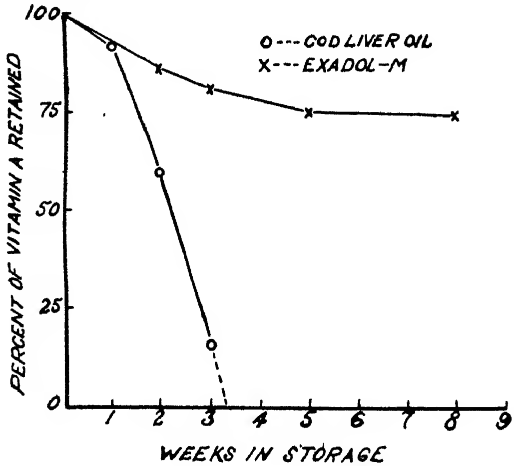
The vitamin A concentration was determined by the Carr-Price antimony trichloride reaction.[3] Nine ml. of the antimony trichloride reagent were added to 1 ml. of the chloroform solution containing vitamin A, and the intensity of the blue (or blue-green) color produced was measured on a Coleman spectrophotometer at 620 mμ. Since the color fades rapidly, the galvanometer reading should be taken at the point of temporary stability, observed about five seconds after adding the reagent. The aliquots for analysis should be so selected that the galvanometer will read between 30 and 70 per cent transmission.[1, 4] The vitamin concentration is calculated using a calibration curve based on vitamin A alcohol or a vitamin A concentrate of known potency.[1, 5]

Results and Discussion

Although no official physico-chemical method for the analysis of vitamin A in mixed feeds has been adopted, the method used in this study has been found satisfactory for following changes in the vitamin conventration. The method is generally regarded as being reliable if the vitamin can be extracted free of substances interfering with the development of the blue color in the Carr-Price reaction.

The stability of vitamin A in the experimental feed mixtures is shown in Figure 1. At the end of the first week 92 per cent of the vitamin A was retained by the feed containing cod liver oil. During the next two weeks the vitamin content rapidly diminished. The value shown for the third week, 14%, is possibly somewhat high, since the color produced in the Carr-Price reaction appeared more pink than blue, probably due to decomposition products extracted with the vitamin. No correction factor was applied to the value obtained at the third week because of the very difficult nature

of the problem involved in arriving at a correction factor and due to the fact only a small amount of vitamin was still retained by the



feed. By the end of the second week the feed containing cod liver oil was quite rancid. It is interesting to note that cod liver oil alone has been found to have an induction period during which it slowly absorbs oxygen, which is followed by rapid oxidation and loss of vitamin A.[9]

Vitamin A is more stable in the feed when added as the oil-molasses emulsion than when added in cod liver oil. Figure 1 shows a gradual loss of vitamin A in the molasses feed, yet at the eighth week over 70% of the original vitamin was retained. This increased stability has probably resulted from the antioxidant effect of the molasses used to make the emulsion. A feed containing vitamin A in an oil-molasses emulsion should provide protection against vitamin A deficiency for several weeks, making it possible to mix larger batches than would be the case when a natural fish liver oil is used.

The data in the present study were obtained by physico-chemical analysis. It is possible that the vitamin A in feeds may undergo a change to some substance which, although still giving the blue color of the Carr-Price reaction, has a lower biological potency. This, of course, can be determined only by bio-assays paralleling the physico-chemical analysis.

Although the stability of vitamin A in large batches of feed, or feeds containing normal quantities of fats and pigments, has not been investigated, probably the vitamin added either as cod liver oil or the oil-molasses emulsion would be stable as long, if not longer, than

found in the extracted feeds used in this study. In larger batches of feed the oxygen of the air will not penetrate so thoroughly and come in contact with the vitamin present. The natural antioxidants present in unextracted feeds also should help preserve the vitamin content.

The extraction procedure previously described easily removes the vitamin A from the feed containing cod liver oil. If the oil-molasses emulsion is not finely distributed in the feed, not only is sampling difficult but good extraction of the vitamin is not obtained by this method. This is probably due to the inability of ether to extract completely the vitamin that may be surrounded by the gums and sugar of the molasses. Preliminary work indicates that a methanol-ether extraction will give satisfactory results with feeds from which ether alone will not remove the vitamin.

The analysis of pigment-free feeds is much simpler than is the case with feeds containing plant pigments such as carotene or the various carotenols. If these pigments are present, a correction factor must be applied for the blue color produced by the reaction of these pigments with the antimony trichloride reagent or an attempt must be made to separate the vitamin from the pigments by chromatographic methods. While both of these methods involve difficulties, developments along both lines may be expected.[1, 5, 6, 7, 8]

Summary

1. A method is described for determining the vitamin A potency of a pigment-free feed mixture.
2. Vitamin A added to a carotenoid-free experimental poultry feed in the form of cod liver oil is rapidly destroyed.
3. Vitamin A added to a carotenoid-free experimental poultry feed in the form of the oil-molasses emulsion is much more stable than when added as cod liver oil alone.

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New Mid-Pennsylvanian Reptiles From Kansas

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It is a matter of much scientific interest to record the discovery in the middle Pennsylvanian deposits of Kansas of two new genera of reptiles, both of them decidedly more advanced than *Eosauravus* from the middle Pennsylvanian near Linton, Ohio. The first of these is represented by a hind limb comprising a nearly complete femur, the distal portions of the tibia and fibula, the entire tarsus and the foot. Probably to be associated with this limb is a small innominate that lay at the same level and only about a yard away. Since no other limb was found that could possibly have belonged with this pelvis, and since its acetabular cup is exactly of the proper size to receive the head of this femur, there seems little chance that the two specimens could have come from different individuals. However, since the two were not in actual contact, we are taking the limb as the *type* of the species which we designate as

*Petrolacosaurus** *kansensis,* gen. et sp. nov.

Holotype: Specimen No. 1424, University of Kansas Museum of Vertebrate Paleontology. A nearly complete hind limb of a pelycosaur, lacking only a small part of the distal articulation of the femur and the proximal half or more of the tibia and fibula (See Fig. 1).

Type Locality: In the Rock Lake shale member of the Lansing group, Missourian series, Pennsylvanian system, about 4½ miles north and 4⅜ miles west of Garnett, Anderson County, Kansas, in the S-E ¼ of Section 32, Township 19 S, Range 19 E.

The specimen was collected by my son, Dr. H. Wallace Lane, from a bed of shale that is clearly marine in nature since it contains brachiopods, crinoid stems and marine bryozoa. It was evidently deposited close to shore since it also contains notable quantities of well-preserved land-plants of several sorts, including *Wallachia* in abundance, mingled with the remains of nectridian amphibians, terrestrial reptiles, and a land-living scorpion. These animal remains do not consist of such widely disassociated parts as would certainly

*The generic name is derived from the Greek *petros,* rock, + *lakos,* lake, + *saurus,* reptile, and is intended to indicate that this reptile is from the Rock Lake shale.

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have been the case had they been carried very far out to sea before deposition and burial.

The Rock Lake shale lies approximately 1300 feet below the top of the Pennsylvanian system and is assigned by the State Geological Survey of Kansas to the *middle* Pennsylvanian. At a point where these specimens were collected this bed of shale is only about two feet in thickness and is overlain by an undisturbed stratum of limestone only a few inches in thickness, which yields various invertebrate fossils that are also typically *middle* Pennsylvanian. There can be no doubt, therefore, as to the age of this deposit and its fossil contents.

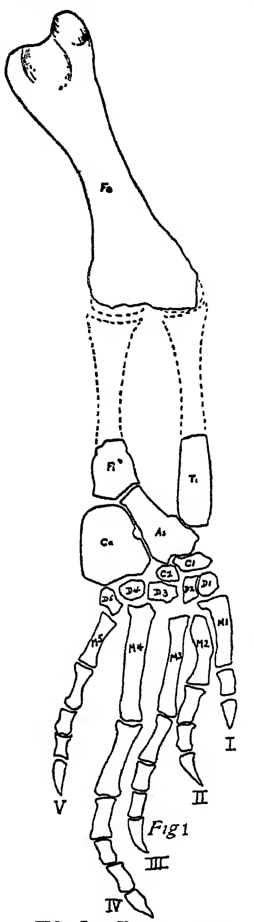

FIG. 1.—Type of Petrolacosaurus kansensis. Hind limb. Drawn by Miss Mary Frances Neidig. Two-thirds natural size. No. 1424 K.U. M.V.P.

Os, astragalus; Ca, calcaneum; C1, C2, centralia 1 and 2; D1-5, distalia 1 to 5; Fe, femur; Fi, fibula; M1-5, metacarpals 1 to 5; Ti, tibia; I to V, digits 1 to 5.

The type specimen (Fig. 1) includes the impression, with much of the bone itself, of an almost complete *femur,* 60 mm. in length as preserved, though the distal end is broken and a short portion of the articular surface may have been lost; the head of the femur is 13 mm. wide; the distal end, as preserved, is 20 mm. across; and the middle of the shaft is only 8 mm. in diameter. Very little crushing by pressure is evident.

Only 12 mm. of the distal end of the *fibula* is preserved and this has two articular surfaces meeting in an obtuse angle of approximately 125°. The lateral articular surface of the fibula abuts against the proximal end of the calcaneum; the mesial, against the astragalus. Only 18 mm. of the distal end of the *tibia* remains, the articular surface of which adjoins the lateral facet on the distal half of the astragalus.

The *calcaneum* (12x15 mm. in width and length respectively) and the *astragalus* (10x15 mm.) are of the forms common among the cotylosaurs and pelycosaurs, for example, in such genera as *Labidosaurus* and *Casea,* but longer in proportion to their width even than in the latter genus.

There are two *centralia* distad to the as-

tragalus: *centrale 1* is oblong, 6x2 mm. in length and breadth. It articulates proximad with the astragalus, distad with distalia 1 and 2, and mesad with centrale 2. *Centrale 2* is only about 1/2 the size of centrale 1, and articulates with the astragalus, centrale 1, distalia 2 and 3, and the calcaneum.

There are five *distalia,* of which 1 and 2 are suturally united but still distinct, and articulate with both centralia, with distale 3, and with the proximal ends of metapodials 1 and 2. Distalia 3, 4 and 5 are all very nearly of a size, 4 being only very slightly larger, and 5 only slightly smaller than the others. *Metapodial* 1 articulates with distale 1; metapodial 2 with distale 2; metapodial 3 with distalia 2 and 3; metapodial 4 with distale 4; and metapodial 5 with distale 5. The *tarsus,* therefore, in this genus is unlike that known in any of the Cotylosauria, and agrees with the Pelycosauria with its two centralia and five distalia. The five *metapodials* also are typically Pelycosaurian. The shortest is the fifth (10 mm.); the longest is the fourth (22 mm.). There is a distinct imbrication of metapodials 1, 2 and 3 at their bases. The phalangeal formula is 2-3-4-5-4. The first *digit* with *2 phalanges* is the shortest; the fourth with 5 phalanges is the longest (ca. 45 mm.); 3, 5 and 2 follow in the order named. The *ungual phalanges* on all the toes are sharply pointed and undoubtedly bore sharp claws in life.

The total length of this limb cannot be exactly determined, since, due to a crack in the shale bed, it had been broken through the *epipodials* (tibia and fibula), the proximal portions of which are lost. The crack in the shale was approximately one inch in width and was filled with yellow clay washed in from the overlying soil. The estimated extreme length of the limb from the head of the femur to the tip of the fourth (longest) toe is 190 mm., or 7 3/4 inches, approximately.

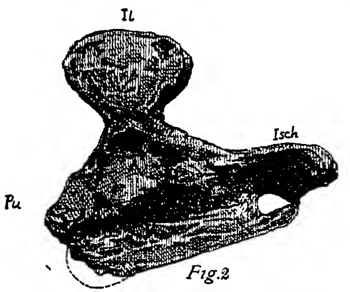

FIG. 2.—Pelvis of Petrolacosaurus. Drawn by Melvin Douglas. Two-thirds natural size. No. 1425 K.U.M.V.P.

A, acetabulum; Il, ilium; isch, ischium; Pu, pubis.

For the reasons given above, we tentatively associate with this limb the small, practically complete *innominate* found at the same level in the bed of shale and not more than three feet away from it (See Fig. 2). This pelvis lacks only a small part of the anterior end of the pubis. Its total length from the present anterior end of the

pubis to the posterior limit of the ischium is 38 mm.; the greatest vertical dimension, from the lowest point of the pubis to the dorsal margin of the ilium, is 33 mm. The *acetabulum* is relatively large, irregularly rhomboidal in shape, and rather shallow for its area. It measures 13 mm. antero-posteriorly and 10 mm. dorso-ventrally. The irregular rim of the acetabulum is not of equal height throughout its whole extent. It is highest on its posterior ischiadic margin and lowest on its antero-ventral pubic margin. Its floor is rather rough and irregular.

The *ilium* is constricted just dorsad to the acetabulum where it has an antero-posterior dimension of 8 mm, and forms a somewhat rounded "neck"; dorsally the ilium expands antero-posteriorly and flattens laterally so that the axe-shaped dorsal portion of this element is 17 mm. in extreme length. Its posterior margin is decidedly thicker than the anterior; the lateral or outer surface of the ilium slopes gradually toward the median plane of the body as it passes posteriorly. That portion of the ilium that enters the acetabulum expands antero-posteriorly to a length of approximately 16 mm. The exact dimension is impossible of determination owing to the fact that the sutures are not visible between any of the elements in this pelvis.

The *ischium* and *pubis* are both concave on their outer surface below the acetabulum, and the long, almost straight ventral margin of these two elements is thin, and forms a distinct ridge or keel in the mid-ventral line of the pelvis. However, in life the ventral surface of the pelvis may have formed a horizontal plate such as is common in many other reptiles, and the apparent keel in the specimen may be due to crushing. There is no ischio-pubic notch nor visible suture to mark the line of union between these two bones. The antero-lateral surface of the pubis is marked by a roughened triangular area which seems to have been produced by the breaking-off of the anterior end of that element. The ischium ends posteriorly in a thickened, antero-ventrally truncated knob. Near the ventral margin of the ischium, just below and in front of this knob, there is a semicircular perforation that is probably accidental. There is no trace of a pubic, nor of an obturator foramen.

All the elements in this pelvis are completely ossified and the whole is excellently preserved. It has not been entirely removed from the original matrix, so that its mesial surface has not been seen. The restoration of the anterior end of the pubis, as indicated

by the broken line in the figure, follows the apparent impression of the bone in the matrix, but no other evidence of the extent of this missing part was found. This pelvis is specimen No. 1425 K.U. M.V.P.

Of the pelycosaurs hitherto known, only one genus is older than *Petrolacosaurus,* and that is *Clepsydrops* described many years ago by Cope from the middle Pennsylvanian near Danville, Illinois, but from a slightly lower horizon than that represented by the Rock Lake shale in Kansas. Most other members of this order come from the upper Pennsylvanian or the Permian.

The Rock Lake shale member of the Lansing group, Missourian series, Pennsylvanian system, in Anderson County, Kansas, has yielded the remains of another important reptile totally unrelated to *Petrolacosaurus* from the same formation. This specimen consists of a practically complete fore limb, the crural, tarsal and pedal portions of a hind limb, in obverse and reverse, a second fore limb, a few trunk vertebrae, a few ribs, and a long series (30 or more) of caudal vertebrae. These remains all pertain to one and the same individual, some of the parts mentioned overlying others in the matrix, and all within an area roughly 8x15 inches in extent. They belong to a hitherto unrecorded form which we designate as

Podargosaurus hibbardi,* gen. et sp. nov.

in honor of Dr. C. W. Hibbard, curator of vertebrate paleontology in the University of Kansas Museum of Natural History.

Type: We designate as the type of this new genus and species the above-mentioned complete left fore limb (#1423, K.U.M.V.P.), comprising the humerus, ulna and radius, the apparently complete carpus, metacarpals and phalanges (Fig. 3). Associated with the type are the other parts of the skeleton mentioned above, which are not so perfectly preserved.

Type Locality: In the Rock Lake shale member of the Lansing group, Missourian series, Pennsylvanian system, about 4½ miles north and 4⅜ miles west of Garnett, Anderson County, Kansas. in the S-E ¼ of Section 32, Township 19 S, Range 19 E. This deposit is assigned by the Kansas Geological Survey to the *middle* Pennsylvanian in time.

*The generic name is derived from the Greek *podargos,* swift-footed, and *saurus,* reptile, in allusion to its long slender legs and feet, which point to its being a fast running lizard-like creature.

The *humerus* of the type (Fig. 3) is 36 mm. long; its convex proximal end is laterally expanded and antero-posteriorly compressed to form the head and the greater tuberosity, and is 12 mm. in its greatest dimension. The head of the humerus is the terminus of a rounded ridge which extends about 18 mm. distad along the mesial margin until it emerges into the somewhat cylindrical shaft of which it appears to be the proximal extension. The distal end of the humerus, lying at right angles to the axis of the head, also expands, but far less than the head, having a transverse dimension of 5 mm. at the elbow joint. This end of the humerus is marked by a median longitudinal groove that extends proximad for about 5 mm. along the anterior face of the bone and separates the radial from the ulnar condyle. This groove leads into what appears to be an *epicondylar* foramen, perforating the humerus. The shaft of the humerus between the two expansions is 8 mm. long by about 3 mm. in transverse diameter. The radial and ulnar condyles are both convex in form.

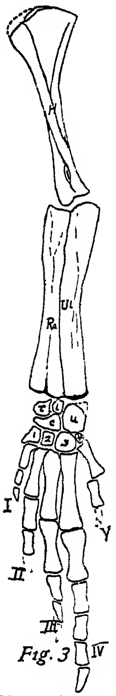

FIG. 3—Type of Podargosaurus hibbardi. Front limb. Drawn by Miss Mary Louise McNown. Two-thirds natural size. No. 1423 K.U.M.V.P.

c, centrale; H, humerus; i, intermedium; r, radiale; Ra, radius; u, ulnare; Ul, ulna; 1-4, distalia; I-V, digits 1 to 5.

The *radius* and *ulna* are about equal in length and stoutness. The former is 39 mm. long. Its proximal end is slightly concave; its distal end is slightly broader than the proximal (ca. 5½ mm.) and is divided by a groove into two condyles. The shaft of the radius is narrowest at about mid-length of the bone, where it is only 3 mm. in diameter. The ulna has an extreme length of 40 mm. Its proximal end is transversely convex, while its distal end is almost square-cut. The proximal end is 5 mm. broad; the distal, 4½ mm. The shaft of the ulna is curved so that its convex margin fits closely alongside the concave mesial surface of the radius and has no marked constriction at any point.

The *carpus* consists of at least eight elements; a pisiform, if ever present, has left no trace of itself. Opposite the end of the radius, is the *radiale*, 5x3 mm. in length and breadth; its mesial margin is convex, its distal margin notched; its lateral margin bears a slight pointed process at its proximal angle; while its proximal

margin is concave. It articulates with the lateral condyle of the radius, with the intermedium and with the centrale. The *ulnare* is roughly rectangular or trapezoidal, with its greatest length (6 mm.) running proximo-distad. Its greatest width is approximately 4 mm.; its mesial margin is a straight line; its lateral margin slightly but irregularly concave. Between the radiale and the ulnare there is a pentagonal *intermedium*, 4 mm. long and only a little more than 1 mm. wide. It would be rectangular were the proximal end not a protruding angle. A large *centrale* is present, 3 mm. long by 4 mm. in greatest breadth. Its mesial margin is somewhat convex and articulates with the ulnare and the third distale: its proximal end is little more than 1 mm. wide and articulates with the intermedium. Its proximo-lateral margin is concave and articulates with the radiale; laterad, for a distance of 1 mm. or less, the centrale is free. Its distal margin is almost straight and articulates with distalia one and two.

The *first distale* is trapezoidal in shape but has its disto-lateral corner prolonged into a rather short conical point, which makes its distal margin concave in outline. This concavity marks its articulation with the first metacarpal. The *second distale* is also trapezoidal in form and articulates with the second and third metacarpals. The *third distale* is the largest of the series and is roughly circular in outline, except on its mesial face where it is flattened to articulate with the second distale. Distally it articulates with both the third and fourth metacarpals. The *fourth distale* is small and almost triangular in shape. It may represent a fused fourth and *fifth distale*, the latter of which is otherwise absent. The fourth lies in a notch between the ulnare and the third distale, with the latter of which it articulates by its mesial face. The base of the triangle is the distal end by which it articulates with the *fifth* metacarpal.

The *first metacarpal* is 5 mm. long, somewhat enlarged and convex at its proximal end where it articulates with the concave distal face of the first distale. The mesial margin of the first metacarpal is practically a straight line; its lateral margin is slightly concave; its distal end is truncate. The *second metacarpal* is 9½ mm. long; it is narrowest at its proximal end (2 mm.) which articulates with the second distale. Its distal end is 3 mm. wide and rather convex in form. The proximal half of the second metacarpal is almost cylindrical in shape; the distal half is somewhat flattened as it broadens out. How much of this difference in shape may be due to crushing, it is impossible to say, but apparently much of it may have been thus

produced. The *third metacarpal* is 13 mm. long; narrowest at its proximal end (ca. 2 mm.), widening 4 mm. distad to 3½ mm. and quickly reducing again to 3 mm., which is the approximate width to its distal end. The proximal 4 mm. in length of this bone is fairly straight; the more distal 9 mm. is gently curved, the concavity being on the mesial side; the convexity, of course, on its exterior side. The proximal end of this third metacarpal appears to be convex; its distal end truncate. The *fourth metacarpal* is 15 mm. long. It is constricted for about 5 mm. along its mid-length. Its proximal end is 3 mm. wide; its distal end 4½ mm. broad and spatulate in form. The *fifth metacarpal* is only 3 mm. long and less than 2 mm. wide; its width varies little throughout its entire length.

The *ungual phalanges* are apparently all sharp-pointed at their distal ends and evidently were clawed in life. The phalangeal formula is: 2-3-4-5-3(?). Only one phalanx is clearly visible in the fifth digit, though it probably had three or four. The phalanges vary in length in accordance with the length of the digits. The longest and largest phalanx is the proximal one of the fourth digit, which is 10 mm. long and 4 mm. broad at each end; its shaft is decidedly constricted at about mid-length. The next largest phalanges are the proximal ones of both the second and third digits, which are both 6 mm. long.

The total length of the limb as it lies undisturbed in the matrix is 135 mm. from the proximal end of the humerus to the distal end of the fourth digit. The metacarpal and phalanges of the first digit have a total length of 12 mm. The corresponding elements of the second digit, 33 mm.; of the fourth, 45 mm.; while only 8 mm. of the fifth digit are visible in this specimen, although it may have been as much as 13 mm., if its distal phalanges maintained the same relative proportions.

Associated Remains: The hind limb is less completely preserved, lacking the femur and most of the tarsal elements. The right hind foot is exposed on the solar surface. The *tibia* is approximately 30 mm. long; its proximal end is convex and rather knob-like; its distal end oblique and articulating with the *astragalus* which is convex on its lateral margin, but lies in such a position that its mesial border is covered by the calcaneum; only about 3 mm. of its length is exposed. The *fibula* is approximately as long as the tibia, expanded at both ends, and articulates distally with the *calcaneum.* The latter

is a large element, about 4x6 mm., rectangular except for its rounded corners. Other tarsal elements are missing.

Of the five *metatarsals,* the fourth is the longest and largest, the first apparently the shortest. The phalangeal formula is evidently 2-3-4-5-3(?), though on account of crushing, the phalanges individually are difficult to make out. As usual the fourth toe is by far the largest.

Only three of the trunk vertebrae are present. They are each 6 mm. long with relatively heavy neural arches 4 to 5 mm. high. There are indications that a small intercentrum may lie between the abutting ends of each pair of vertebrae on the ventral side. The series of *caudal vertebrae,* or impressions thereof, extends over a distance of 105 mm. and in life comprised 30 or more elements. This made a very long slender tail. There are some half dozen curved, *single-headed ribs,* the longest about 20 mm. long, measured over the outer curvature, all evidently belonging to the trunk region.

The second fore limb rests on its side in the matrix and exhibits no feature not found in the type. Fragments of femora, shin bones, tarsals and phalanges are also present in the slab but add nothing to our knowledge of the species.

The long slender limbs, the very long tail, almost thread-like at its termination, the single-headed ribs, the humerus with an epicondylar foramen,—all these characters are suggestive of the Lower Permian *Araeoscelis* described many years ago from Texas by Williston. In the absence of the skull, however, it is impossible definitely to place *Podargosaurus* in the order *Protorosauria* to which provisionally *Araeoscelis* and a few other genera have been assigned. Beyond a shadow of doubt, *Podargosaurus* does not belong to either the cotylosaurs or the pelycosaurs; the Protorosauria, therefore, provide about the only other resting place for it. The age of *Podargosaurus*—middle Pennsylvanian instead of lower Permian—may mean merely that the earlier protorosaurs have not hitherto been found, and that the order originated farther back in time than the previous records indicate. In the slenderness of its limbs and feet, *Podargosaurus* is unlike any other known type of reptile of its time, unless it be a protorosaur, and for that reason we assign it to that order.

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The Influence of Set on the Learning and Retention Concepts

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INTRODUCTION

The general problem of this experiment was to investigate the influence of set as determined by different instructions upon the learning and retention of concepts. The specific problems were the following: 1. How does set influence the rate of learning and retaining concepts? 2. Is there a differential rate in learning and retaining between logical and illogical concepts acquired within the same set? 3. Is there a differential rate in the learning and retaining of concepts acquired in different sets? 4. How does the rate of retaining conceptionalized nonsense syllables compare with that for nonconceptionalized syllables? 5. How does set influence the acquisition of the relative frequency of logical and illogical concepts? 6. How does set influence the process of acquiring concepts?

In this experiment a concept is defined as any process of the individual that enables him to respond in a desired or controlled manner to given stimuli. A logical concept is a response that is given only to stimuli which have certain obvious characteristics in common, such as the word "bird" for feathered and flying animals. An illogical concept is a response given to a mixed group of stimuli which have no obvious characteristics in common, such as the word "bird" for airplanes, crows, trees, and love.

The materials used in this experiment consisted of six nonsense syllables, each of which represented a certain familiar logical category, 168 familiar English words grouped into 42 sets of four words each, and 42 cards, 3½ by 5 inches. On the face of each card was printed a set of four words one of which belonged to a category symbolized by the syllable which was printed on the back of the card. To avoid position habits the key word occurred in irregular positions; to make memorization difficult the order of the syllables was different in every six cards and the same syllable never occurred on two adjacent cards.

EXPERIMENTAL PROCEDURE

In the experimental procedure, the experimenter presented the cards from behind a screen to the view of the subject at the rate

of one card every seven seconds measured by the beats of a metronome. On the third second the experimenter pronounced the nonsense syllable on the card and on the fifth second he withdrew the card in view and prepared to present the next one. If the subject named a card correctly, the experimenter said "Right". If the subject failed to name the card or named it incorrectly, the experimenter prompted him. The 42 cards were always presented in a constant order. One showing of these cards completed a trial or repetition, after which there was a rest interval of 15 seconds except when introspective reports were recorded, when the time was extended to the necessary length. The introspective reports on the process of learning or concept formation were regularly taken every third trial, and oftener if there was evidence of unusual progress. To secure these reports the experimenter asked, "What suggests *kun*?", and the same for each of the other nonsense syllables. At the end of the last trial, the question was changed to the following form, "What is *kun*?" If the answers were thought to be inadequate, the experimenter asked, "In what ways have you tried to learn the names of these cards?" The experimenter recorded the following data on forms prepared for the purpose: the response made to each card; the number of promptings required to respond correctly to each card; the number of repetitions required to reach the first errorless trial; the total time required to learn or relearn a given series; and the observations and reports of the subject whether made voluntarily or in response to the experimenter's questioning. Each test was an individual one, and only the records of those subjects who completed the task at one sitting were used for the quantitative results.

Fifty-one college students served as subjects. By means of the Henmon-Nelson intelligence test they were divided into two approximately equal ability groups, called Groups 4 and 5, and into five approximately equal sub-groups. Group 4 included sub groups 4*a*, 4*b*, 4*c*, and group 5 included sub-groups 5*a* and 5*b*. The *a* groups relearned after one week, the *b* groups after three weeks, and the *c* group after six weeks.

To give the reader a more concrete idea of the materials used in this experiment, we present here the name and content of each of the cards:

Name	Content
1. Kun	horn leaf monkey debt
2. Vor	brook leave claim precious

3.	Yem	roses suit juice plum
4.	Bep	climb picnic reaches best
5.	Dax	answer highest airplane red
6.	Jik	pine hear speak chalk
7.	Yem	fight tablet chair poppy
8.	Kun	fame ought tiger saucer
9.	Bep	potato careful pasture raised
10.	Jik	across oak floor sorry
11.	Vor	lover borrow flower point
12.	Dax	anywhere green aloud apple
13.	Vor	honey idle breaking bread
14.	Jik	pencil cedar just crossing
15.	Yem	doesn't spread dandelion stuck
16.	Bep	crawl turnip pleasant closet
17.	Dax	board beast blue butter
18.	Kun	line people elephant sound
19.	Vor	broken darling load pearl
20.	Kun	uncle fried sheep pear
21.	Yem	enough hitch lily tangle
22.	Jik	break knee maple eyes
23.	Dax	building purple believed plus
24.	Bep	call o'clock carries spinach
25.	Yem	sunflower ditch shade stir
26.	Jik	bid know file walnut
27.	Vor	barrel sweetheart hurried noisy
28.	Bep	coffee pilot clay carrot
29.	Dax	bunch brown borrow prince
30.	Kun	crowd sail deer string
31.	Bep	berry nickel tomato calm
32.	Dax	maid arrow lean yellow
33.	Jik	because sugar elm meat
34.	Kun	horse circle paid scholar
35.	Yem	toward leader pansy treated
36.	Vor	banana haste dear minutes
37.	Dax	orange beat ankle knives
38.	Yem	laden daisy disgust cranky
39.	Vor	believe cigar owe love
40.	Kun	carrying died cow ruler
41.	Bep	urn cabbage crown swept
42.	Jik	air hour cheat cottonwood

To each subject was read one of the following sets of directions:

Directions No. 5 for members of Group 5.

I am going to show you a number of cards, one at a time. Each of these will be named by a nonsense syllable, such as jok, bif, or hex. Look carefully at the cards and try to learn as soon as you can the name of each card. At first you will not know the names of any of them and I shall have to prompt you. I shall always prompt you when you fail to tell me the name of a card within three seconds after it has been shown. When I have given you the name of a card *repeat it aloud after me* so that I can be sure you understand it. Your work will be finished as soon as you can name each card without any help. Now will you answer this question:

What are you to do?

Directions No. 4 for members of Group 4.

This is an experiment in learning concepts. A concept, you know, is a word, or idea that stands for any one of a group of things. Thus, the word chair, bird or stone stands for no particular chair, bird or stone, but for any one of a group of chairs, birds, or stones. I am going to show you a number of cards, one at a time. Each of these cards will be named by a nonsense syllable, such as jok, bif, or hex, and each nonsense syllable is a concept. Look carefully at the words on the cards and try to learn as soon as you can the name of each card and what it stands for. At first you will not know the names of any of them and I shall have to prompt you. I shall always prompt you when you fail to tell me the name of a card within three seconds after it has been shown. When I have given the name of a card *repeat it aloud after me* so that I can be sure you understand it. Your work will be finished as soon as you can name each card without any help. Now will you answer these questions:

1. What is this an experiment in?
2. What is a concept?
3. In this experiment, is each nonsense syllable supposed to be a concept?
4. What are you to do?

As soon as each subject answered the question or questions to the satisfaction of the experimenter, the learning was begun.

It should be observed that the essential difference between the two kinds of dirctions is that a member of Group 5 must learn only

the name of each card while a member of Group 4 must learn not only the names but should also secure their meanings. We shall now present the answers to each of our problems as they are indicated by the results obtained.

Results

1. The influence of set upon the rate of learning and of retention

After due consideration of the different measures used, we selected the mean number of promptings per concept as the measure of learning and of relearning, and the percent of promptings saved in relearning as the measure of retention. Table I sets forth the results showing the influence of set upon the learning and retention of concepts.

Table I

Influence of Set on Learning and Retention of Concepts. Group 5, Set to Learn Names. Group 4, Set to Learn Names and Meanings.

		Promptings per Concept				
		Learning		Relearning		
Group	No. Concepts	Mean	S.D.	Mean	S.D.	Percent Retention
5ab	126	40.85	18.55	2.08	2.87	94 91
4ab	114	30.70	13.40	1.35	1.76	96.58
Difference		10.15		.73		1.67
S. E. Difference		2.05		.28		

There is clearly an immense advantage in having a specific set for learning the meaning of concepts. When there is no such set the amount of work required to learn is one-third greater. The advantage for relearning and retention is not so great but it is still noticeable.

2. The relation of the method of learning to the economy of concept formation within the same set.

Regardless of the kind of instructions given some concepts were learned by means of associations based upon accidents of position, similarities in sensory quality, and irrelevant contiguous words chosen to hide the key word, while others were based upon the key words that fitted the logical categories selected. The former procedure led to illogical while the latter led to logical concepts. A concept was considered to be logical or correct if the subject either named the proper category or if he named the key words belonging to the category; but if he included words that did not belong, the concept was classified as illogical or incorrect. After separating the two groups of concepts, the mean number of promptings required to learn and relearn each group was computed. Table II gives the results of these computations.

TABLE II
Mean Number of Promptings Required to Learn and Relearn Logical and Illogical Concepts.

Group	No. Concepts	Method	Promptings per Concept: Learning M.	Learning S.D.	Relearning M.	Relearning S.D.	Percent Retention
5ab	85	Logical	37.41	20.35	1.22	2.12	96.6
	41	Illogical	45.41	13.10	2.06	2.22	92.2
	Difference		8.00		.84		4.4
	S. E. Difference		3.01		.41		
4ab	98	Logical	29.19	12.05	.91	1.61	95.3
	16	Illogical	40.13	17.10	2.06	2.22	92.6
	Difference		10.94		1.15		2.7
	S. E. Difference		4.44		.58		
5ab Logical—4ab Logical			8.22		.31		
S. E. Difference			2.52		.28		
5ab Illogical—4ab Illogical			5.28		.00		
S. E. Difference			4.81		.60		
5ab Illogical—4ab Logical			15.22		1.15		
S. E. Difference			2.52		.28		

We see that within the same set, illogical concepts require a great deal more effort to learn than logical ones. When the set is to learn names only (Group 5ab) the amount is about one-fifth greater, and when the set is to learn both names and meanings, the amount is about one-third greater. These differences are large enough to be statistically significant. We conclude then that within the same set there is a differential rate of learning in favor of logical concepts. The same is true for relearning but to a much smaller degree.

3. The relation of the method of learning to the economy of concept formation for different sets.

If there is a difference between the rates of learning logical and illogical concepts within the same set, we would expect this difference to be increased when these methods are used in different sets. That this is the case is shown in the lower part of Table II. It requires about fifty percent more effort to form an illogical concept when the set is general (5ab) than it does to learn a logical concept when the set is specific for the purpose (4ab). Even a logical concept is formed with much less effort if the set is to learn both name and meaning (4ab) than when it is to learn names only (5ab). The same is true for illogical concepts but to a somewhat lesser degree.

4. Comparison of rate of forgetting for concepts and nonsense syllables.

Those familiar with the rate of forgetting nonsense syllables must have been impressed with the high percentage of retention shown in Tables I and II for conceptionalized nonsense syllables, all of which are over 90. These are for an interval having an average length of two weeks (the average of one-week and of three-week intervals). In contrast, the Ebbinghaus curve for retention shows a retention of less than 25 percent and that of Radossawljewitsch a

retention of 41 percent for an interval of two weeks. As already stated, our main groups were divided into sub-groups a, b, and c, the members of which relearned their series after one, three, and six weeks respectively. Table III shows the percentages of retention for these intervals for logical and illogical concepts in relation to their sets or groups, and for the sake of comparison also gives the corresponding values for nonsense syllables as determined by Ebbinghaus and Radossawljewitsch.

TABLE III

Percentages of Retention for Logical and Illogical Concepts in Relation to Set and for Nonsense Syllables.

Group	Mean Percentage of Retention After		
	One week	Three weeks	Six weeks
4 Logical	97.6	95.6	96.0
Illogical	95.4	91.2	89.2
5 Logical	97.3	95.0	
Illogical	94.2	89.5	
Nonsense syllables			
Ebbinghaus	25.4	22.8*	18.2*
Radossawljewitsch	49.3	38.0	16.3*

*Interpolated from curve.

By comparing the rows of Group 4 with those of Group 5 we notice that a set to learn both names and meanings is more favorable to retention than a set to learn names only. By comparing the rows for logical concepts with those for illogical concepts we notice that logical are better retained than illogical concepts. By comparing the rows for conceptionalized nonsense syllables with those for unconceptionalized or mere nonsense syllables we notice an enormous difference in favor of concepts. The retention curves for concepts have an almost imperceptible fall whereas those for nonsense syllables are precipitous. This is a fact of tremendous significance for education.

5. The influence of set on the relative frequency of logical and illogical concepts.

Looking back at Table II, we see that Group 5, set to learn names only, acquired 85 logical and 41 illogical concepts. In other words, 67.4 percent of the concepts were logical. In contrast, Group 4, set to learn names and meanings, acquired 98 logical and 16 illogical concepts. This means that 86 percent of its concepts were logical. Compared with a set to learn names only, a specific set to learn names and meanings increases the proportion of logical concepts.

6. The influence of set on the process of concept formation.

The quantitative results described in the foregoing tables may be understood in terms of the different processes used to reach the

goals. It is the purpose of this section to clarify this statement.

If we examine the materials used in this experiment we see that the number of possible ways to learn the cards is large. A subject may memorize the order of the syllables, but this is very difficult for 42 syllables. He may associate each syllable with the first word on each card, or with the second, third or fourth words, or with some combination of these positions. He may associate the syllables with words that have common letters or sounds, or he may try to form associations between syllables and various groups of words. Of the last method there are many variations. For example, *kun* may be thought to stand for people, living things, parts of the body, wild beasts, or simply animals. Similarly each of the other syllables may be thought to stand for an equal variety of groups. Examples of the aforementioned methods may be found in the records for the members of both Groups 4 and 5, but there is this difference: In Group 5 (set to learn names only) the subjects far more frequently than those in Group 4 (set to learn both names and meanings) learn the names of the cards by associating them with position and order, with common letters between syllables and words, and with words that are unrelated to each other. In contrast the members of Group 4 avoid much of this nonsensical procedure and begin to look for relationships and groups of words which might be connected with each syllable. After two or three trials they find one that works. This success encourages them to look for another, and after a variable number of further trials (usually 1 to 6), the subject responds correctly to all the cards. We shall now present the records of some individual subjects to illustrate the aforementioned procedures.

GROUP 5

Case I

Subject No. 7. Group 5b, freshman girl, nearly always makes the top score in every test in her psychology class. Henmon-Nelson score 52 An example of slow learning by a superior student because of letter associations none of which lead to logical or correct concepts.

Date 11/17/43 Time begun: 3:11
Time ended: 3:55

Trial 1. S (Subject) "What am I supposed to be doing?" S didn't look at the cards but at E (Experimenter). E explained again.

Trial 3. *Kun*=usually a word with *c*, don't know.
Vor=don't know.
Yem=*y* at the end of a word as in *pansy*
Bep=don't know.
Dax=don't know.
Jik=don't know.

Trial 4. *Vor*=usually *ber* and *bro*.*
Yem=*y*.
Dax=several words beginning with *b*.

Trial 6. *Kun*=first card, don't know.
Vor=*bor, bre, bar,* and first word of each card.
Yem=*y* (usually in third word), sometimes *en* in first word.
Bep=first word begins with *c* as in *correct*.
Dax=usually three words beginning with the same letter, *b*.
Jik=usually a*k* or a*c* somewhere in the word.

Trial 7. S appears very discouraged because of the failure.

Trial 8. S broke down and began to cry at beginning of trial, at 3:55 p.m., and said: "I just can't do it". S was excused and asked to come back "day after tomorrow at 11:00".

Date: 11/20/43 Time begun 11·00
Time ended 12·17

Trial 8. *Kun*=*c,* and first word.
Vor=first word, B, *bor, bar, broken, banana,* brought.
Yem=*y* at end of word, sometimes ion, pansy, attention.
Bep=first word starts with *c*.
Dax=all four words begin with *b, 2 b's, 2 p's,* or 4 *b's* or 3 *b's, 2 c's*
Jik=usually *k* in third word, or *k* in second or third word.

Trial 12. *Kun*=always a *c,* don't know.
Vor=*bor, bro, ba, be.* Subject pronounces vor as bor.
Yem=*y* at end of word, pansy, *ion* in one place, etc.
Bep=two words beginning with *c,* just word beginning with *c, be* as in berry.
Dax=3 words beginning with *be,* or words beginning with *be,* 3 words with *a*.
Jik= a *k* or *c* in second, third, or fourth words.

Trial 18. *Kun*=one *ion C* in *crowd*.
Vor=same as trial 12.
Yem=same as trial 12, also 2 or 3 words with *s*.
Bep=same as in trial 12.
Dax=same as in trial 12.
Jik=same as in trial 12.

Total time	111 minutes
Total trials	18
Total promptings	389
Average promptings per concept	64 83
Average promptings per concept, Group 5	40 85

Retention Test‾ Date 12/8/43 Time begun: 3:11
Time ended· 3:25

Trial 1. *Kun*=live, male.
Vor=words beginning with *b* like *bor, ber, bre, banana*.
Yem=*ion* in dandelion, 3 *s's* in one card, *y* the last letter in some words.
Bep=*be* in first word, often first word begins with *c*
Dax=words beginning with *be, 4bs* on one card, 2 *bs* on one card, 2 *bs* and 2 *pa* on one card.
Jik=*c* with *k* sound as in *cottonwood, j* followed by *k* sound.

Trial 2. No changes.

Total time	14 minutes
Total trials	2
Total promptings	6
Average promptings per concept	1
Average promptings per concept for Group 5b, relearning	2.57

*Items in *italics* occur in stimulus cards.

GROUP 4

Case 5

Subject No. 56, Group 4b, freshman girl, Henmon-Nelson score, 36. A case of approach to logical concepts through various hypotheses, excellent retention.

Date 2/3/44 Time begun: 2:02
Time ended: 2:54

Trial 3. *Kun*=don't know.
Vor=something about love, *sweetheart.*
Yem=don't know.
Bep=some of them might be a vegetable.
Dax=*highest, borrow.*
Jik=don't know.

"I have tried with words starting with *c* for *kun* but it doesn't work. Tried to remember the order, but that's too hard."

Trial 5. *Kun*=*cow.* I pick out a word on each card.
Vor=*love, sweetheart, dear.*
Yem=Is it a vegetable? That's what I have been going by.
Bep=*A* vegetable, too, more than the *yem.*
Dax=Pertaining to money, *borrow highest.*
Jik=*cottonwood.*

Trial 6. *Kun*=animal.
Vor=*love, sweetheart, dear.*
Yem=don't know.
Bep=vegetable.
Dax=pertaining to money.
Jik=tree.

Trial 7. *Yem*=flowers.
Dax=same as before.

Trial 8. *Kun*=animal.
Vor=*precious,* don't know group.
Bep=vegetable.
Yem=flower.
Dax=that's the color.
Jik=tree.

Total time	52 minutes
Total trials	8
Total promptings	190
Average promptings per concept	31.67
Average promptings per concept, Group 4b	29.40

Retention Test Date: 2/24/44 Time begun: 8:47
Time ended: 8:51

Trial 1. *Kun*=animal.
Vor=love.
Yem=flower.
Bep=vegetable.
Dax=color.
Jik=tree.

E: "How did you discover the meaning of *vor*?"

S: "First I didn't know what *vor* was. Thought it out right after the first test. Went over them by myself this morning."

Total time	4 minutes
Total trials	1
Total promptings	0
Average promptings per concept, Group 4b, relearning	1.43

The first observation that may be drawn from the foregoing illustration and other original records is that the members of Group 5, set to learn names only, make many more false starts than those of Group 4, set to learn both names and meanings. They begin with hypotheses that lead to wrong responses and lose much time in eliminating them. Often they fail to reach a logical hypothesis but succeed in reaching the learning criterion with an illogical one. In contrast, the members of Group 4 often get the correct start from the first or if they do make false starts, they were quick to discard them and get on a track that led to logical concepts.

The second observation that may be drawn from these illustrations and the original records is that there is no uniform method of forming concepts. Each individual arrives at his goal by his own methods. Nevertheless there are some steps which occur often enough to enable us to sketch some landmarks along the way. They may be designated as follows:

First, a period of doubt and orientation.
Second, a period of search and trial solutions.
Third, a period of evaluation and checking.

These periods occur in practically all our cases but not without overlapping. What occurs in each period and how long it lasts varies with the individual and the set under which he learns. As our illustrations and records show, the members of Group 5 waste much time in associating the syllables with words that have common letters and sounds and with continuous words that are unrelated to each other. These lead to conflicting responses and require much effort to segregate and differentiate, but eventually become well enough organized to lead to correct responses. Some of the members of Group 4 also follow this procedure and with the same consequences, but the majority of them, after a brief period of orientation, begin looking for groups of words which they can attach to the syllables. This procedure makes for easy learning and retention. For example, if the subject learns that *dax* means color, he simply recognizes the name of a color on the card and says, *dax,* but if he has to learn that in one *dax* card, the four words begin with *b,* in another one there are 2 *b's,* in a third one there are 3 *b's,* in a fourth there are two *c's,* and in a fifth there are two *p's,* he will suffer a long period of hard work and many disappointments.

A third observation that may be made from the illustrations and records is that learners form many kinds of concepts any one of which may lead to the correct response. Psychologically any concept which leads to the correct or desired response may be called correct, but logically this is not the case. We have divided the concepts into logical and illogical ones, but within each group there are subdivisions which may be distinguished. It should also be pointed out that logical concepts differ not only logically but also psychologically from illogical ones. They are simpler, require a less specific stimulus, have a higher degree of redintegration, and are more generalized. The subdivisions which may be distinguished are as follows:

1. Illogical concepts
   A. Contiguous or similar elements (letters, sounds)
      Kun= a word with *c* or *k*.
      Vor=*bor, bro, ba, be.*
      Yem=*y* at the end of a word.
      Bep=*be.*
      Dax=3 words beginning with *be*, 3 words beginning with *a*.
      Jik=a *k* or *c* in second, third or fourth word.
   B. Contiguous or similar units (words)
      Kun=*cow, people, rose, uncle.*
      Vor=*lover, honey, believe, brook.*
      Yem=*enough, toward.*
      Dax=*building, bunch, apple.*
      Jik=*across, airplane, cottonwood.*

2. Logical concepts
   A. Contiguous related units (words)
      Kun=sheep, cow, horse, tiger, deer, elephant.
      Vor=sweetheart, honey, dear, precious, lover
      Yem=roses, daisy, pansy, lily.
      Bep=beets, carrots, turnip.
      Dax=yellow, red, blue, brown.
      Jik=cottonwood, oak, pine.

   B. Definitive or class name
      Kun=animals.
      Vor=love or endearing terms.
      Yem=flowers.
      Bep=vegetable.
      Dax=color.
      Jik=tree or wood.

The foregoing subdivisions may represent stages in the genetic development of the concepts for some individuals, but it is also true that each subdivision represents the terminal stage of the concept for others. This experiment has shown that the definitive stage may be reached by most subjects if the proper set is created.

Summary

The general problem of the experiment reported here was to discover the influence of set on the learning and retention of concepts. The materials used consisted of 42 cards, each of which had four unrelated English words on the face and a nonsense syllable on the reverse side. There were six nonsense syllables each of which represented a logical category to which one of the words on the face of the card belonged. The student's task was to learn the name of each card and was finished when he reached his first errorless trial in naming the 42 cards.

The procedure involved the presentation of these cards at the rate of one card every seven seconds and the prompting of the subject when he failed to name the card within three seconds. A record was made of the number of promptings required to learn each card, of the subject's observations, of his process of learning, and of the concept he formed for each syllable.

Firty-one college students divided into two groups served as subjects. One group was instructed to learn only the names of the cards and the other to learn both names and meanings. The chief results are as follows:

1. A set to learn meanings as well as names increases greatly the rate of learning and improves retention.
2. Concepts logically formed are learned more quickly and better remembered than those illogically formed.

3. The differential rate between learning and retaining logical and illogical concepts is greater between different sets than within the same set.
4. The curve of retention for conceptionalized nonsense syllables falls almost imperceptibly and contrasts sharply with the curve for nonsense syllables, which falls precipitously.
5. A set to learn names and their meanings yields a much larger proportion of logical concepts than a set to learn names only.
6. The aforementioned quantitative results may be understood in terms of the difference in processes used to reach the goals. Subjects instructed to learn names and their meanings search much more frequently for logical relationships than do those instructed to learn names only.

Micropycnodon, New Name for *Pycnomicrodon* Hibbard and Graffham *not* Hay.

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The name *Pycnomicrodon* proposed by Hibbard and Graffham for a genus of upper Cretaceous fish (Univ. Kans. Sci. Bull., Vol. 27, Pt. 1, No. 5, p. 72, December 30, 1941) is preoccupied by *Pycnomicrodon* Hay 1917, (Bull. Univ. Texas, Sci. Ser., No. 71, p. 6, December 20, 1916). Therefore, we propose to substitute for *Pycnomicrodon* Hibbard and Graffham *not* Hay, the new generic name *Micropycnodon,* the genotype becoming *Micropycnodon kansasensis* (Hibbard and Graffham).

Prairie Studies in West-Central Kansas: 1943

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Great changes in environment produce striking reactions throughout the plant and animal world. During the past decade or more, the native vegetation of west-central Kansas has undergone significant changes in response to wide variations in its environment. In order to measure these vegetative changes in considerable detail at Hays, Kansas, numerous meter-quadrat areas were staked out and charted for annual readings in 1932. The quadrats whose vegetative changes are included in this report were located in an exclosure so as to include vegetation representative of the area where the short grasses of the table land met and in places intermixed with the mid grasses of the slopes and ravines.

Variations in Environment

Precipitation, soil moisture, temperature, wind movement, and evaporation are the chief factors that govern the behavior of native vegetation.

Average precipitation during the 6-year period (1927 to 1932) was 27.76 inches, nearly 5 inches above normal (Albertson and Weaver, 1942). This period of bountiful rainfall was followed by one of 7 years duration when the average annual precipitation was nearly 5 inches below normal. During four of these years (1933-'34-'36-'39) it was approximately 7 inches below average, and for the remaining years, it was considerably below normal. The drought was broken late in the fall of 1939 and precipitation in 1940 was approximately normal. In 1941 and 1942 it was again 5-6 inches above normal. This two year wet period was followed by a year of intense drought with only 16.2 inches of moisture.

The amount of soil moisture is directly dependent upon precipitation. The supply of soil water carried over from the moist period of 1927-32 was depleted to a depth of 3 feet by the end of June, 1933, and during the remainder of this season it was only intermittently present to this depth. For the subsequent drought years, moisture was never available below 2 feet and for weeks at a time none was present to 5 feet. Even normal precipitation in 1940 did

little in restoring moisture to the parched, dry soil. In 1941-1942, however, available soil moisture was restored to a depth of 5 feet for the first time since 1933, but the drought of 1943 again depleted much of the soil moisture stored in the two preceding years.

Temperature, likewise, fluctuates greatly. It usually becomes more intense during periods of extreme drought, but is considerably reduced during times of sufficient rainfall. Normal wind movement is slightly over 36,000 miles for the six summer months at Hays, Kansas. It was more than 2,000 miles above normal for the seven-year drought period, but from 1940 to 1943 it was slightly below normal. Average evaporation from a free water surface is approximately 48 inches for the growing season, April to September. During the drought, however, it was nearly 57 inches and for several years it even extended above 60 inches. For the wet year of 1942, evaporation was less than 42 inches.

Change in Species and Percent Basal Cover of Native Vegetation

The prairie vegetation in this section of the state is naturally divided into three general types (Albertson, 1937). The short grasses dominate the table lands. Little bluestem and its associates comprise the second type and are found on the hillsides where the underlying rocks are close to the surface. The third type is found in the ravines and lowlands where big bluestem is the dominant species.

The native vegetation in the exclosure in which this study was made, however, is divided into the short grass type, the little bluestem type, and the mixed type where the short and mid grasses come into contact with each other.

THE CLOSED SHORT GRASS TYPE

The percent basal cover of the two short grasses, blue grama (*Bouteloua gracilis*) and buffalo grass (*Buchloe dactyloides*) varied from 80 to 90 percent in 1932 (Fig. 1A). This cover was shared about equally by the two dominants. It decreased rather abruptly and was approximately 25 percent in 1937. There was a slight increase during the season of 1938, but the intense drought of 1939 was responsible for the all time low of less than 20 percent in 1940. Increase was rapid during the following two years. The average cover was approximately 95 percent in the fall of 1942 and the drought of 1943 reduced it only slightly. It is significant that during the period of decreased cover, blue grama (Bgr) suffered less than did its co-dominant buffalo grass (Bda). The response of buffalo

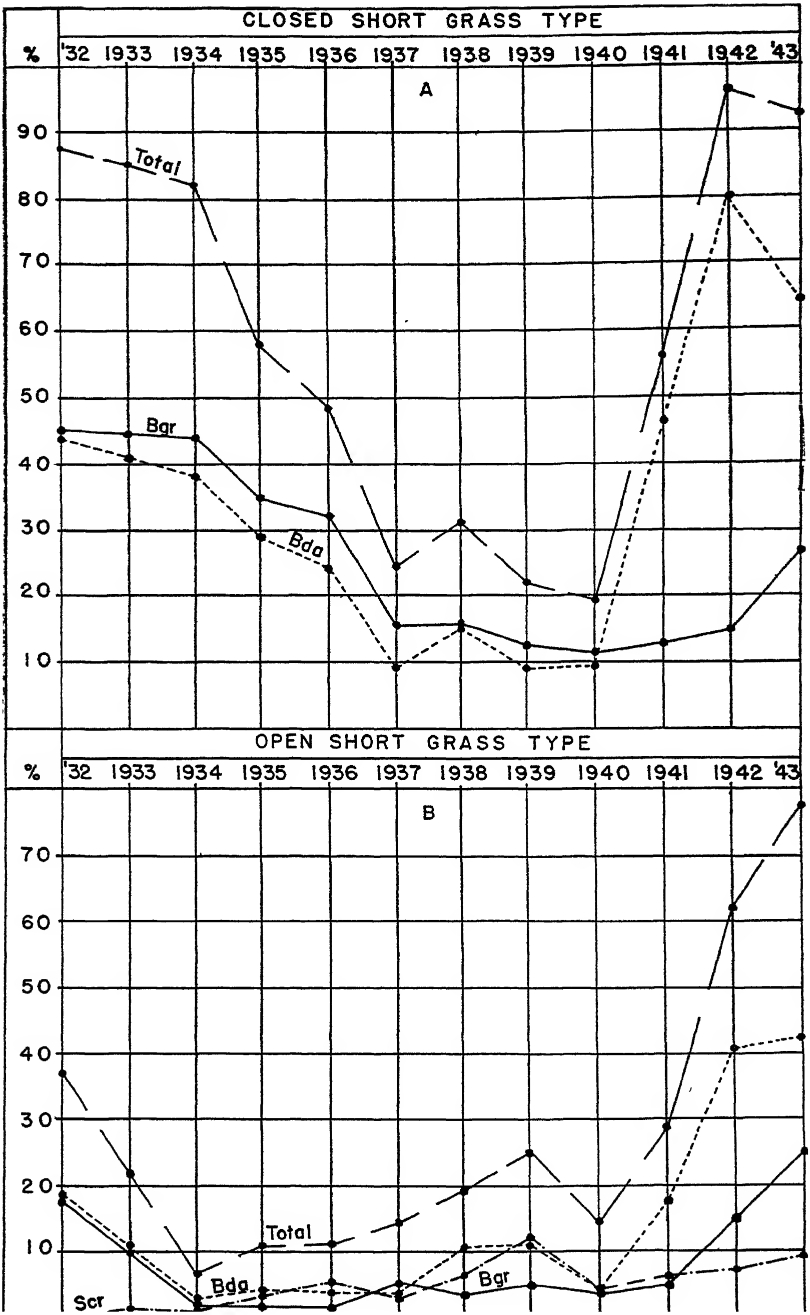

FIG. 1.—Change in percent of total basal cover, and cover of blue grama (Bgr), buffalo grass (Bda), and sand dropseed (Sir) on (A) closed short grass type, and (B) open short grass type at Hays, Kansas, during a twelve-year period.

grass to better growing conditions, however, was very striking. The cover of this species increased from less than 10 percent in the fall of 1940 to 80 percent in the fall of 1942. During this same two-year period blue grama gained less than 2 percent. It is also significant that buffalo grass lost approximately 15 percent during the dry year of 1943, whereas blue grama gained over 10 percent.

OPEN SHORT GRASS TYPE

Local depressed areas scattered among the short grasses are clothed with a sparse cover of the two short grasses and occasionally sand dropseed (*Sporobolus cryptandrus*). The total cover in 1932 averaged slightly less than 40 percent (Fig. 1B). It was reduced to about 6 percent by 1934, but thereafter gained gradually until 1939 when the total was slightly less than 25 percent. The carry over effect of the drought in 1939 again reduced the basal area to approximately 15 percent in 1940. During the next three years it rose to an all time high of nearly 80 percent. Blue grama and buffalo grass remained nearly equal in abundance during the first two years of the drought, after which blue grama was slightly more abundant for three years. The nearly normal precipitation of 1938, however, furnished the stimulus for buffalo grass to make fairly substantial gains until 1939 when it lost heavily during the late fall drought. The cover in 1940, therefore, was only 5 percent. Both short grasses increased steadily during 1941 and 1942. Blue grama even continued to spread during 1943 in spite of drought. Sand dropseed (Scr) made its first appearance during the growing season of 1933. It gained only slightly until 1938, but during the following year it increased its cover to over 10 percent, after which there was a rapid decrease during 1940 and only a slight gain thereafter.

The Little Bluestem Types

The mid grasses on the slopes vary in density according to the depth of soil overlying the rock strata. If the slope is gentle with considerable accumulation of soil, the plant cover is fairly dense and forms a closed type of vegetation. On the steeper slopes, however, where little or no soil remains the vegetation is sparse, forming an open cover.

CLOSED LITTLE BLUESTEM TYPE

Little bluestem (*Andropogon scoparius*) and big bluestem (*A. furcatus*) were the only grasses of any importance in the closed type in 1932. Side oats grama (*Bouteloua curtipendula*), blue grama and buffalo grass, however, became important as the drought pro-

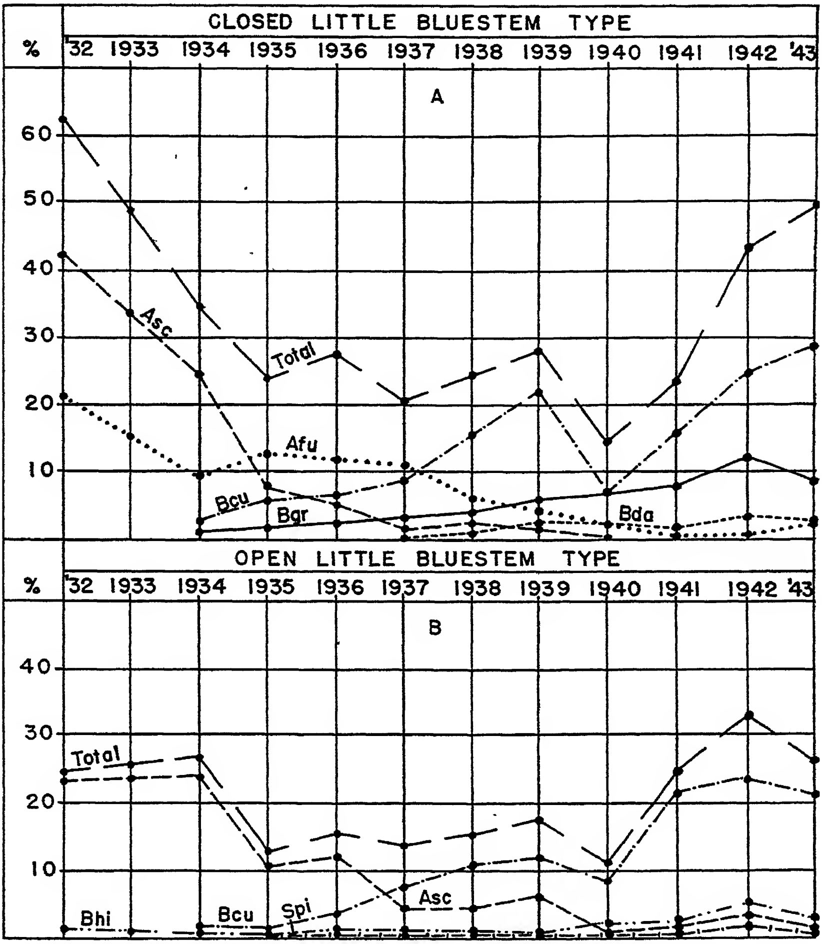

FIG. 2.—Change in percent of total basal cover, and cover of little bluestem (Asc), big bluestem (Afu), side oats grama (Bcu), blue grama (Bgr), hairy grama (Bhi), hairy dropseed (Spi), and buffalo grass (Bda) on (A) closed little bluestem type, and (B), open little bluestem type at Hays, Kansas, during a twelve-year period.

gressed. The total cover in this habitat was slightly over 60 percent in 1932 (Fig. 2A). By 1935 it had dropped to about 25 percent. A slight increase occurred during the following season, but in 1937 the impact of the drought of 1936 was reflected in a reduction of the total cover to approximately 20 percent. A gradual increase occurred during the following two seasons and a cover of 28 percent was found in the fall of 1939. The carry over effect of the drought of 1939 is shown in the abrupt decrease to only 15 percent during

the season of 1940. It increased rapidly each year thereafter and amounted to nearly 50 percent in the fall of 1943.

Little bluestem (Asc) constituted the bulk of the vegetation of this type in 1932. Loss was rapid, however, and by 1937 scarcely any remained and the drought of 1939 was all that was required to reduce it to nil. Its co-dominant, big bluestem (Afu) furnished about half as much cover as did little bluestem in 1932. Its loss during the first two years of the drought was similar to that of little bluestem. A slight gain was found during the season of 1935 after which the decline was gradual until 1942 when its cover was less than 2 percent. The increase in 1943 was negligible. Side oats grama (Bcu) was absent from all areas under study until 1934. After its appearance, however, steady gains were made and by 1939 it furnished a cover of more than 20 percent. A sharp decrease occurred because of the autumn drought of 1939 and only about 5 percent was present in the fall of 1940. Thereafter the increase was significant and nearly 30 percent was charted in the fall of 1943. This species of grass very largely replaced the two bluestems during the period of drought and the subsequent favorable years. Blue grama (Bgr) also invaded this type in 1934. It gained steadily and reached its maximum cover in 1942. Even buffalo grass (Bda) gained entrance and has maintained a small cover since 1937.

OPEN LITTLE BLUE STEM TYPE

The total cover on the abrupt slopes where the vegetation was most open averaged only about 25 percent in 1932 (Fig. 2B). A slight increase occurred during the first two years of drought after which there was an abrupt decrease to approximately 12 percent. From this date until 1940 when it was 11 percent the total cover changed but little. It increased rapidly after 1940 and reached its maximum of approximately 32 percent in the fall of 1942. The drought of 1943 caused a slight decrease.

Little bluestem (Asc) constituted all the cover in 1932 except about 2 percent of hairy grama (*Bouteloua hirsuta*). Side oats grama and hairy dropseed (*Sporobolus pilosus*) appeared later in the drought period. The total cover and that of little bluestem ran nearly parallel from 1932 to 1935, but thereafter, they were significantly different. The loss in cover of little bluestem continued and was less than 1 percent in 1940, after which it increased slightly to 3 percent in 1943. Thus little bluestem, the dominant in 1932, was relegated to a very minor position during the following two years.

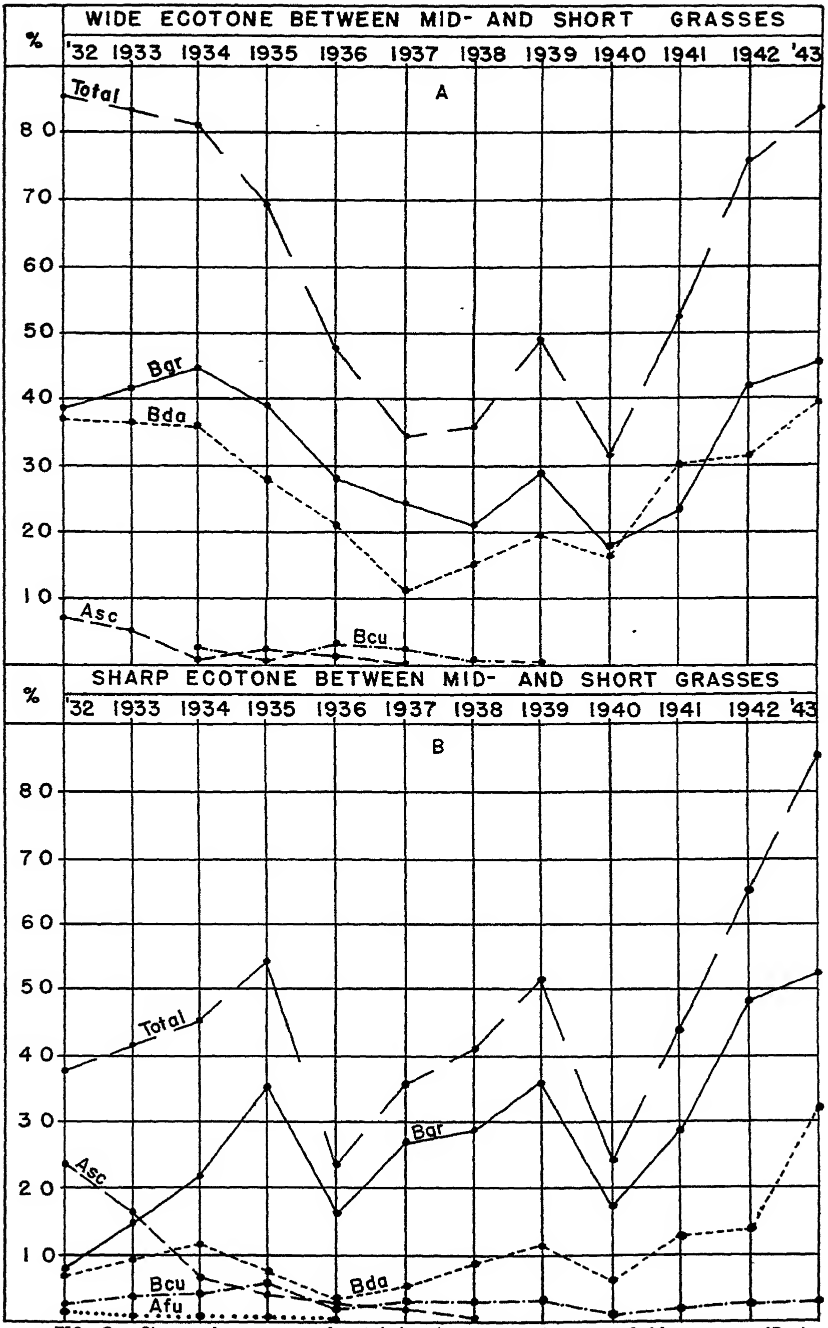

FIG. 3.—Change in percent of total basal cover, and cover of blue grama (Bgr), buffalo grass (Bda), little bluestem (Asc), side oats grama (Bcu), and big bluestem (Afu) on (A) wide ecotone between mid- and short grasses, and (B) sharp ecotone between mid- and short grasses at Hays, Kansas, during a twelve-year period.

Side oats grama (Bcu) made its first appearance in 1934 and gained rapidly after 1935. It reached about 12 percent in 1939 and then decreased to about 9 percent in 1940. Its increase in 1941 and 1942 was about 13 percent when it reached its maximum cover. A small decrease occurred in 1943. Hairy grama (Bhi) was never important but was always a definite part of this type. Hairy dropseed (Spi) appeared in 1935 and maintained more than 1 percent cover thereafter.

Ecotone Between Short Grasses and Mid Grasses

If the slope is gentle where the short grasses and mid grasses meet, considerable mixing of the two types of grasses occurs. Under these circumstances the short grasses constitute a lower story with scattered bunches of little bluestem or other mid grasses forming an upper one. If the short grasses and mid grasses meet where there is an abrupt change in topography, however, very little inter-mixing of the two types is found, therefore the line or ecotone between the short grasses and mid grasses is sharp.

Total cover on the broad ecotone was about 85 percent in 1932 (Fig. 3A). The loss was only gradual for two years, indicating a more mesic condition in this location than in the short grass type a few yards distant. The full impact of the drought was first felt during 1934 and the loss in cover was extremely abrupt between 1934 and 1937. It is significant though that the cover of 34 percent was nearly 10 percent greater than in the short grass type (Fig. 1A). A small gain occurred in 1938 and a further gain in 1939. The fall drought of 1939, however, reduced the cover to approximately 32 percent, the low mark of the drought for this type. The total cover rose rapidly after 1940 and was nearly back to its original amount of 85 percent in 1943.

It should be noted that the two short grasses constituted the large portion of the perennial vegetation in this type. Blue grama (Bgr) gained slightly during the first two years; then the cover continued to decrease rather abruptly until the fall of 1938 when it was slightly over 20 percent. Its gain to nearly 30 percent in 1939 reflected the carry over effect of the favorable year in 1938. The loss in 1940 was likewise due to the fall drought of 1939 and was in proportion to the decrease in total cover. After 1940 there was a steady gain and by 1943 the basal area was about 44 percent. Buffalo grass (Bda), like blue grama constituted slightly less than 40 percent in 1932 . During the first two years, however, it suffered a

slight loss in contrast to the small gain by blue grama. From 1934 to 1937 its loss in cover was abrupt and reached a low point of only 11 percent. It responded rapidly to the nearly normal precipitation in 1938 and gained about 8 percent between 1937 and 1939. After suffering a slight loss in 1940 it gained steadily and maintained a cover of 39 percent in 1943. Little bluestem was present only in scattered bunches and averaged only 8 percent cover in 1932. The loss was abrupt during the next two years and less than 1 percent remained in the fall of 1934. It was present only as a relict from 1934 to 1937 after which it was absent. Side oats grama appeared in 1934 and remained as a small cover until 1939. The drought of this year, however, was sufficient to obliterate it. The two short grasses were therefore the only species in this habitat that could withstand the ravages of drought.

The behavior of vegetation on the sharp ecotone was quite different from that on the preceding type. In 1932, for example, the total cover was 38 percent, slightly less than half of that on the broad ecotone (Fig. 3B). In definite contrast to all other types, the cover gained approximately 15 percent during the next three years and was about 52 percent in 1935. Drought effects were slow to become apparent in this type, but great losses were found in the extremely dry season of 1936 when only 22 percent cover remained. Significant gains occurred during the next three years and in 1939 the cover was again nearly 52 percent. The fall drought of 1939, however, reduced the basal area to approximately 26 percent after which there was a rapid increase and a cover of 84 percent was found in the fall of 1943. The part played by the various species is significant. The area occupied by blue grama (Bgr), for example, closely followed that of the total cover. Little bluestem (Asc), on the other hand, decreased rapidly from 24 percent in 1932 to nil in 1938. Buffalo grass (Bda) appeared not to be as well adapted to this type of soil as was blue grama; its cover of 8 percent in 1932 was similar to that of blue grama, but during the succeeding years its increase was much less. Side oats grama (Bcu) constituted about 4 percent cover in 1932. It gained slightly until 1935 but decreased to about 2 percent in 1936 and changed very little thereafter. Big bluestem (Afu) was present in a very small amount in 1932 and disappeared completely in 1936.

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Note on a Giant Kansas Calamite and the Ottawa Fossil Forest

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Calamites are Carboniferous fossil horsetail rushes which are represented today by about 25 species of the single genus *equisetum.* Calamites were plants with numerous, hollow, jointed, and ribbed stems which grew in wet or swampy sandy soils in jungle-like areas resembling the modern southern canebrakes or bamboo thickets. At the nodes along the stems were branchlets which were often arranged in whorls, and these bore circlets of leaves at their nodes. Unlike the modern horsetail rushes, which are generally less than three feet tall (except for a South American species that grows from 30 to 40 feet in height and is one inch in diameter), the Carboniferous calamites were very much larger than their living descendants. Calamite specimens less than six inches thick are common. Some calamites, however, attained diameters up to three feet and heights as much as 100 feet.

This note is to record an unusually large or giant Kansas calamite which I observed last November (1943) while mapping and studying Thayer coal in the Chanute shale formation in eastern Kansas. The fossil plant is an internal sandstone mold consisting of a segment 34 by 28 inches in diameter and 8 inches thick. This specimen, therefore, approaches the maximum known size attained by calamites. On the basis of its diameters, this plant while growing might have reached a height of fully 100 feet. As far as I am aware this is the largest calamite specimen ever recorded for Kansas. It was found in Neosho County at a Thayer coal outcrop located near the head of a draw about two-tenths of a mile west of the section-line road and approximately on the south line of the NE¼ sec. 9, T. 28 S., R. 18 E.

A very interesting and unusually excellent exposure of calamites in situ occurs about two miles west of Ottawa, Franklin County, in a road cut on highway U. S. 50 S. between Ottawa and Emporia. At the outcrop are several calamites ranging from one-half to three inches in diameter and from five to six feet tall. The calamites are in the form of internal sandstone molds, standing in a vertical or upright position with their lower parts rooted in the Ottawa coal (Fig. 1). The Ottawa fossil forest is especially note-

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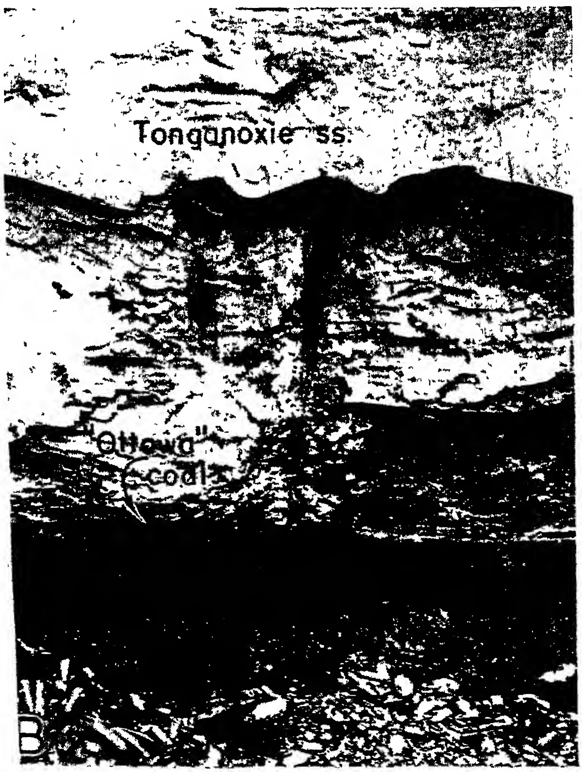
worthy for several reasons. First, this is one of the few places where ancient vegetation still in place and undisturbed is fully exposed to view; second, the relation between vegetation and coal is clearly demonstrated, namely that coal is formed from vegetation; and third, observation of the fossil forest gives one a good idea of the type of vegetation that flourished near Ottawa some 225 million years ago.

Stratigraphically, the Ottawa calamites occur in the Tonganoxie sandstone member of the Stranger sandstone formation, Douglas group, Virgilian series, Pennsylvanian system, whereas the giant Neosho County calamite which is 400 feet stratigraphically lower is from the Cottage Grove sandstone member of the Chanute shale formation, Kansas City group, Missourian series, Pennsylvanian system.



Calamite in situ with lower part rooted in coal, outcrop on U. S. 50 S. about 2 miles southwest of Ottawa, Franklin County, Kansas. (Courtesy State Geological Survey of Kansas.)

Correlations Between Scores on the Modified Alpha Examination Form 9 and Grades in Various High School Subjects

J. W. DEMAND
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In the fall of 1941, the students of Concordia Senior High School were given the Modified Alpha Examination, Form 9. This mental test, published by the Psychological Corporation, New York City, consists of 76 numerical and 144 verbal items.

This year a mental testing program was inaugurated in the High School, and much comment was aroused as to the value of such tests. Since grades in various subjects were available for most of those students who had taken the Alpha Examination, they were used to determine the correlation of scores on the Alpha Examination with academic success.

The courses in which enough grades were available for correlation were sophomore English, junior English, social civics, American history, biology, and geometry. The grades were assigned on a five-point scale and correlated with the total raw scores made on the Alpha Examination. In Table I, the classification of the students represents their classification at the time they took the test. The juniors and seniors have graduated and the sophomores are now seniors. The latter class is now taking the course in social civics so no grades are available for this group in that course.

TABLE I
Correlations Between Scores on Modified Alpha Examination and Academic Grades

	Seniors			Juniors			Sophomores		
Courses	N	r	PE	N	r	PE	N	r	PE
Sophomore English	94	0.82	0.02	77	0 73	0.04	77	0.65	0.04
Junior English	93	0.64	0.04	77	0.71	0.04	77	0.74	0.03
Social Civics	94	0.63	0.04	76	0.71	0.04			
American History	95	0.67	0.04	74	0.64	0.05	74	0 54	0.06
Biology	79	0.54	0.05	67	0.74	0.04	55	0 67	0.05
Geometry	38	0.44	0.09	42	0.69	0.05	33	0.56	0 08

Although the number of students in each class is not large (this is especially true in geometry) the correlations are quite high in the majority of cases. In the senior and sophomore geometry classes the correlations are low, but more information is necessary to de-

termine whether this is due to a sampling error or a mathematical weakness in the test.

The Henmon-Nelson Test of Mental Ability for college students was one of the tests included in the testing program for seniors. To indicate the comparative values of this test and the Alpha Examination the correlations between the Henmon-Nelson test and various grades are given in Table II. The class in Table II is the same as the sophomore class in Table I. There were not enough scores available in geometry to warrant computing a correlation.

TABLE II

Correlation Between Scores on the Henmon-Nelson Test and Grades in Various Subjects

	Seniors (Sophomores in Table I)		
Courses	N	r	PE
Sophomore English	65	0.59	0.05
Junior English	64	0.63	0.05
American History	62	0.32	0.08
Biology	49	0.60	0.06

When the relationship between the scores on the Alpha Examination and the Henmon-Nelson test was computed, the correlation was found to be 0.74 + 0.04. The correlations between sophomore and junior English, American history, and biology and the Alpha Examination are all higher than they are with the Henmon-Nelson test. The greatest difference found in correlations is 0.22 in American history.

In conclusion, the above results seem to indicate that the Alpha Examination, Form 9, might profitably be included in a high school mental testing program. Besides possessing what seems to be a rather high correlative value it is so constructed that high school students are quite interested in taking the test.

Membership of the Academy

ABBREVIATIONS: The following abbreviations for institutions have been used:
U.K.—University of Kansas.
K.S.C.—Kansas State College of Agriculture and Applied Science.
K.S.T.C.—Kansas State Teachers College.
F.H.K.S.C.—Fort Hays Kansas State College.
H.S.—High School.
Jr. H.S.—Junior High School.
Jr. Col.—Junior College.
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Members who paid their 1944 dues before publication of this list are indicated by an asterisk (*). The year given is that of election to membership. If two years are given, the second signifies reinstatement. All addresses are Kansas unless indicated otherwise. Names of members in the armed services are being carried on the rolls for the year 1944-45.

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Junior Academy of Science Clubs

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NECROLOGY

The Academy announces with deep regret the death of the following members:

HAMILTON PERKINS CADY

Hamilton Perkins Cady was born at Skiddy, Kansas, May 2, 1874, and died at Lawrence, Kansas, May 26, 1943. He received his secondary education at the Oberlin, Ohio, High School and Carleton College Academy at Northfield, Minnesota. Early in 1894, the family returned to Council Grove, and young Cady entered the University of Kansas. He majored in chemistry in his undergraduate work and was graduated in 1897. He was granted a scholarship and later a fellowship for two years of graduate research work at Cornell University. In 1899 he returned to the University of Kansas as assistant professor of chemistry, and resumed his work with liquid ammonia in collaboration with Dr. Franklin, receiving his doctorate in 1903. The same year, Dr. Franklin was called to Stanford University and Dr. Cady at once took over Dr. Franklin's courses and work in inorganic and physical chemistry. He advanced rapidly and became chairman of the department on the retirement of Dr. E. H. S. Bailey in 1920.

Dr. Cady, in 1907, in collaboration with Dr. Bailey, published the first edition of a *Laboratory Manual of Qualitative Analysis.* Five years later he published his *Inorganic Chemistry* and in 1916, his *General Chemistry.*

In 1907 Dr. Cady, together with David McFarland, discovered helium in a sample of natural gas sent from Dexter, Kansas. This discovery, important both theoretically and practically, led to Dr. Cady's appointment as a consultant for the U. S. Bureau of Mines during World War I. In later years he became interested in the determination of exact molecular weights of gases and vapors and devised a special balance for the direct determination of these quantities.

Not only was Dr. Cady a distinguished investigator, but he was as well an extraordinarily able teacher and lecturer; his lectures on liquid air, given hundreds of times over the state, will long be remembered and served to attract many students to science as a profession.

Dr. Cady was not only a native Kansan and long a resident of the state but he was devoted to its institutions and to none was he more loyal than to the Kansas Academy of Science. A member

since 1904 and a frequent contributor to the *Transactions,* he was also president of the Academy in 1923-24.

The Academy has seldom suffered so grievious a loss in a single year as in the deaths of two past presidents, Dr. J. W. Hershey and Dr. H. P. Cady.

J. WILLARD HERSHEY

Dr. J. Willard Hershey, who was head of the department of chemistry, McPherson College since 1918, died September 27, 1943 at the age of 67. He was born on February 6, 1876, at Gettysburg, Pennsylvania. As a boy he attended the public schools near Gettysburg, was graduated from the Millersville State Normal School, and received both the B.S. degree in 1907, and the M.S. degree in 1910 from Gettysburg College. He studied at Harvard in 1907 and 1908; at Johns Hopkins in 1910 and 1911; and the University of Chicago, receiving his doctor's degree from that institution in 1924.

During his work at McPherson College, Dr. Hershey brought fame to the college as well as to himself. He was internationally known for his experiments in making synthetic diamonds. The largest synthetic diamond, about the size of a common pin head, is credited to Dr. Hershey. He continued his work with the hope that still larger diamonds might be made which would have a definite commercial value.

Dr. Hershey also achieved a wide reputation for his work on the effect of the rare gases, especially helium, upon animal life. He was the author of three books: *Qualitative Analysis; Laboratory Manual of General Chemistry;* and the *Book of Diamonds.* He was a frequent contributor to these *Transactions* and to other scientific periodicals and was one of the most active members of the Academy. He joined the Academy in 1920, served on many committees and filled a number of offices, becoming president in 1933.

JOHN RAYMOND HORTON

Mr. John Raymond Horton was born in Ogden, Utah, on August 4, 1881, and died April 7, 1944, at Wichita, Kansas, at the age of 62.

Mr. Horton graduated from the Utah Agricultural College in 1906. From 1906 to 1909 he was assistant entomologist of the Utah Agricultural Experiment Station. He was associated with the Bureau of Entomology and Plant Quarantine, United States Department of Agriculture since 1909. For the past 26 years he lived at Wichita, Kansas, and was in charge of the United States Ento-

mological Research Laboratory. His insect investigations were on insect pests attacking wheat, oats, corn, and grain sorghums. Mr. Horton was for over twenty years a member of the Kansas Academy of Science and in 1941 became a life-member of our organization.

WILLIAM BENJAMIN PARKS

Dr. William Benjamin Parks was born August 31, 1863, at Lancaster, Texas, and died May 22, 1943, at Pittsburg, Kansas, at the age of 79.

Dr. Parks received his B.S. degree in 1886; M.A. in 1892, and Ph.D. in 1894 from Texas Christian University, and his M.S. degree in 1920 at the University of Chicago. He was professor of chemistry from 1887-1899 and 1904-1917 at Texas Christian University; he also served as dean from 1910-1917 at the same university. He was head of the department of chemistry at Southwestern Oklahoma Teachers College from 1918-1921, and professor of chemistry at Oklahoma Agricultural and Mechanical College from 1821-1923.

Dr. Parks, in the fall of 1923, began his work in chemistry and other duties at Kansas State Teachers College, Pittsburg, and continued full-time work until July, 1939, at which time he began partial retirement, and two years later full retirement. He became a member of the Academy in 1931.

W. D. ROYER

Mr. W. D. Royer was born at Newton, Kansas, January 30, 1888, and died at Wichita, Kansas, March 5, 1944, at the age of 56.

Mr. Royer received his elementary education at a rural school, completing academy work at McPherson College and was graduated from McPherson College in 1913. He was a teacher at Enterprise, Kansas, High School, principal of Sterling, Kansas, High School two years, head of the science department of the Abilene, Texas, High School two years, and a teacher of science in the Wichita High School East for 23 years. During the years Mr. Royer was engaged in teaching, he also took graduate work at Kansas University, Wichita University, Wisconsin University, and Colorado University. Mr. Royer became a member of the Kansas Academy of Science in 1927.

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Transactions
Kansas Academy of Science

Volume 48, No. 1 | June, 1945

The Colorado Desert of California: Its Origin and Biota

T. D. A. COCKERELL
The Desert Museum, Palm Springs, California
and the University of Colorado, Boulder.

Previous reviews in this series have dealt with Kansas subjects as will many of our future reviews. Lest we develop too provincial an attitude, however, we will occasionally present other than Kansas topics. The present article, from the pen of one of our leading naturalists, describes the geology and biology of an American region but little known to most Kansans. Professor Cockerell in developing his topic has considered briefly such interesting subjects as the history of the Rocky Mountains and of the Grand Canyon, thus giving us knowledge that will add to our enjoyment and understanding when we can again take to the western highways. The article, too, should be of interest to others than professional biologists as an example of the biologist's method of approach and of thought in the description of a region.

It may also be remarked that Kansans are somewhat sensitive on the question of deserts when it is recalled that long ago we were once placed on maps as part of the Great American Desert. The more recent publicity given the Dust Bowl area has re-aroused our sensitivities on this score. Since the Colorado Desert, however, is in California we may all read this interesting and important account of an American desert with double enjoyment.

For further information concerning the author, see page 42.—THE EDITOR

The Colorado Desert was named by Professor W. P. Blake of the U. S. Geological Survey in 1853, when there was no State of Colorado. There are two great deserts in southern California: the Mohave and the Colorado, the second being the lower and more southern. Going through the Morongo Pass, one passes in a short time from the one desert to the other. Blake[1] originally described the boundaries of the Colorado Desert as follows:

It extends from the base of Mount San Bernardino to the head of the Gulf of California and is separated from the coast-slope by the Peninsula Mountains [the present Coast Range]. The limits of the plain on the north and northeast are determined by ranges of mountains which extend from San Bernardino Mountain to the mouth of the Gila [the mountains are now known as the San Bernardino Range and the Chocolate Mountains] and beyond into

Sonora. On the south and east, the Desert is bounded by the Colorado River and the Gulf. The area thus bounded is a long and nearly level plain, extending in a northwest and southeast direction, from latitude 34° on the north to the parallel of 32° on the south.

Blake goes on to say that the greatest length of the Desert is 180 miles and its greatest width 75 miles, with an approximate area of 8,250 square miles. (See map, page 6).

Modern physiographers[2] have dropped the term "Colorado Desert" and have included its area in the Sonoran Desert-Salton Sea Section, a section which includes a number of deserts known locally and shown on various maps as the Mohave Desert, the Colorado Desert, the Yuma Desert, the Gila Desert, the Grand Desert, and the Sonoran Desert. As this paper shows, the Colorado Desert contains features which differ to some extent from other areas in the general region; sufficiently different that W. P. Woodring[3] remarks, "The name Colorado Desert . . . I think should be revived as a general regional name comparable with Mohave Desert. Unfortunately it has fallen into disuse and no other name except 'Salton Sea Region' or 'Salton Basin', which are less satisfactory, has taken its place. Coachella Valley and Imperial Valley cover only part of the area."

To Woodring's comment it may be added that biologists recognize the Colorado Desert, and distinguish between it and the Mohave Desert. To one who knows these deserts this is perfectly intelligible, and nothing is gained by abandoning the name in favor of separate distinctions for small areas or, on the other hand, using one name for the whole arid region of southern California. Munz (*Manual of Southern California Botany,* 1935, p. xvii) gives a good account of the matter as follows:

Although on first thought, the Colorado and Mohave Deserts may appear to be of the same general nature, further analysis shows them to be quite distinct in regard to certain features. In a general way their topography is somewhat similar, both having typical xerophytic vegetation. The outstanding differences become evident through a more detailed analysis of each individual flora and through a knowledge of the affinities of each.

Of the sum total of desert species recorded, nearly 20% are found on the Colorado Desert alone, while about 35% are found only on the Mohave. These figures can be accounted for when it is seen how much more extensive the Mohave Desert is in comparison to the Colorado Desert. Here it will be interesting to note that about 45% of the entire desert flora is common to both deserts.

"The Mohave Desert region comprises the extreme southwestern portion of the Great Basin." This statement of C. L. Baker (Notes on Later Cenozoic History of the Mohave Desert Region in southwestern California, *Calif. Univ. Dept. Geology, Bull. 6,* 335-336, 1911) immediately suggests the main affinity

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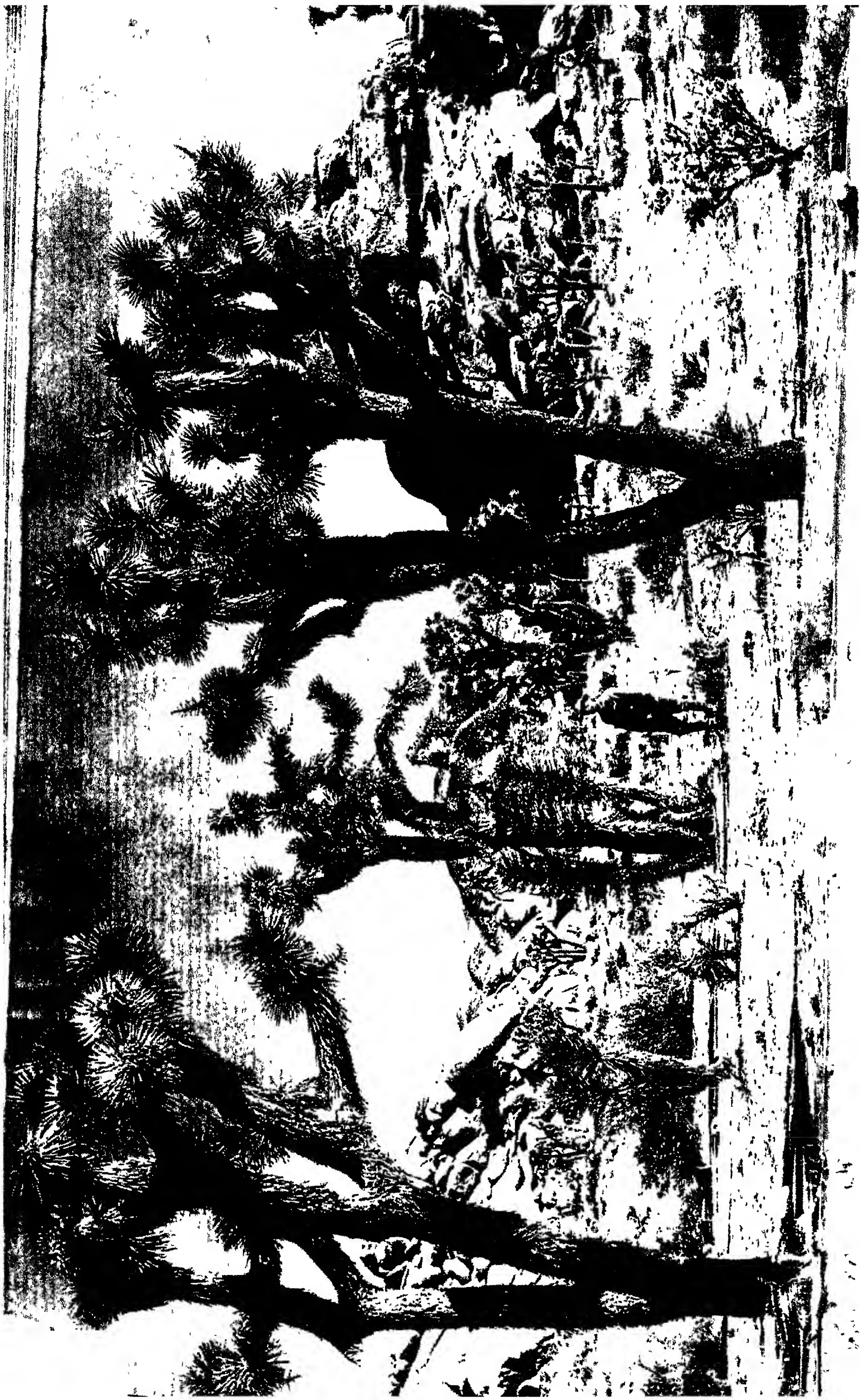
☛ This view across a part of the Coachella Valley in the Colorado Desert shows [illegible] specimen of the native palm, Washingtonia, in the center of the view, a denser clun[illegible] palm at the right and Mount San Jacinto (10,800 feet), in the background.—Ward p[illegible]



of the Mohave Desert region, this being substantiated by the fact that about 94% of the Mohave Desert flora which is not endemic, is of Great Basin affinity.

The term *desert,* as applied to these areas, is rather misleading. Typical deserts, such as I have visited in North Africa, Peru, and northern Chile are barren stretches of sand, sometimes extending hundreds of miles, though there may be a fertile oasis here and there. Our California deserts are largely covered with vegetation, mostly shrubs, which are spaced here and there as if planted. There should be a different name for this kind of desert; it is indeed a *Xerophytic area,* but this designation is not likely to become popular.

In order to get some idea of the origin of the Colorado Desert it is necessary to consider its geological history, and to begin with a brief history of the Rocky Mountains, the significance of which will appear later on.

The Rocky Mountains

In Colorado the eastern base of the mountains, now some five-thousand feet or more above sea level, was in Upper Cretaceous times a sea coast. In many places it is possible to find marine shells, oysters, Inoceramus, cephalopods, and other forms. At Boulder there is an exposure of the Pierre Cretaceous in the midst of the town, and one day J. T. Duce, who had collected fossil insects with me, picked up a rock containing a cephalopod shell, but his keen eye noted a small projecting object, which he thought might be an insect wing. This did not seem very probable, but by careful chipping, the whole wing was exposed; it was a new genus of Homoptera. The little insect had been accidentally drowned in the sea and the piece of rock testified at once to the marine conditions and the near proximity of land.

In Tertiary times, subsequent to the Cretaceous, we find in Colorado abundant evidence of an exuberance of mammalian life and an extensive flora of trees and shrubs. The Green River formation, extending into Wyoming and Utah, and including the oil shales, is of Eocene age. The name Green River is perhaps a little misleading, as there was no Green River when the beds were laid down.

At Florissant, near Pikes Peak, is the very famous deposit in

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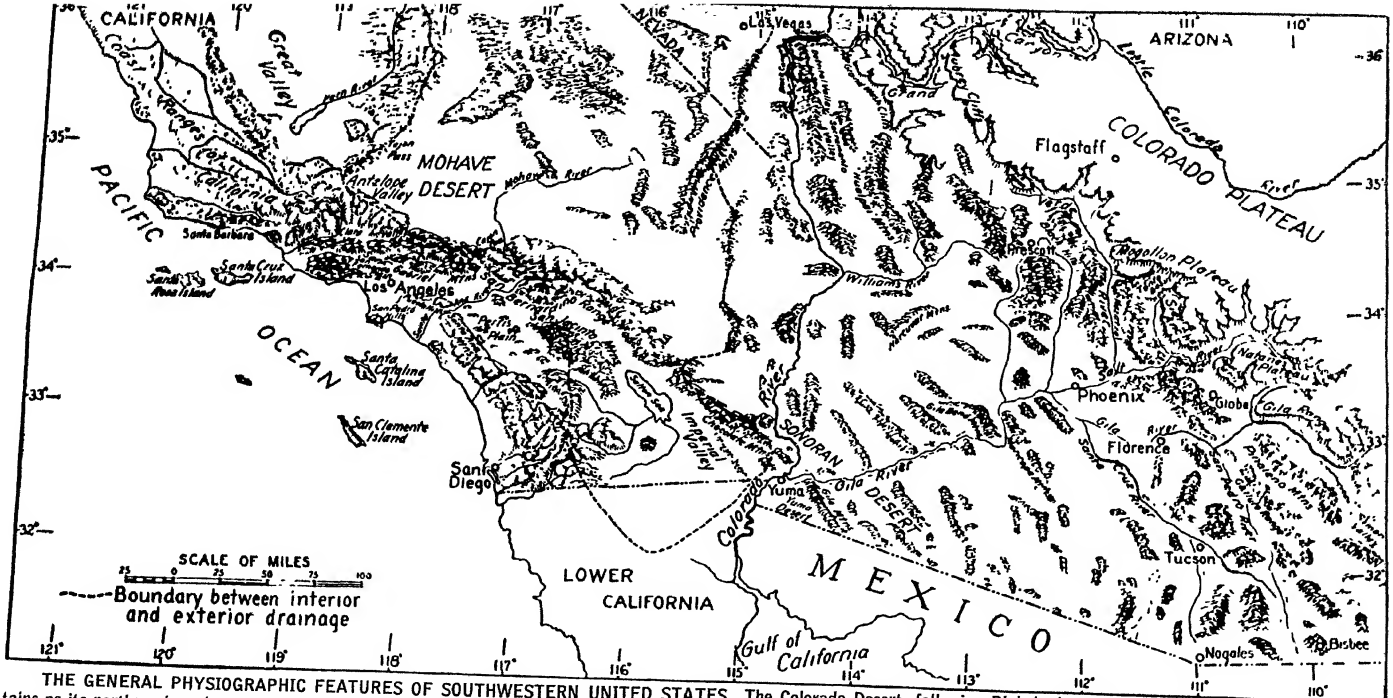
☛ This photograph was taken in Lost Horse Valley in the Joshua Tree National Monument, some twenty-five or thirty miles from the photograph on the opposite page. The typical plant life here shown is the grotesque Joshua tree, which as pointed out on page 23, does not come down into the Colorado Desert. The Joshua Tree National Monument lies on the north-eastern slope of the San Bernardino Mountains, the mountains dividing the Mohave from the Colorado Desert.—Photograph, courtesy the National Park Service.



THE GENERAL PHYSIOGRAPHIC FEATURES OF SOUTHWESTERN UNITED STATES. The Colorado Desert, following Blake's description, has the San Bernardino Mountains as its northern boundary and the San Bernardino, the Chocolate Mountains and the Colorado River as the eastern boundary. It extends as far south as the Gulf of California. The western boundary consists of the coastal mountains, beginning in the Santa Ana Mountains on the extreme north and extending southeasterly parallel to the coast. The Imperial Valley, the Salton Sea, the Coachella Valley (northwest of the Salton Sea and lying between the San Bernardinos and the San Jacintos), the San Jacinto Mountains and the Santa Rosa Mountains (the latter range not shown on the map, but extending southeastward from the San Jacinto Mountains), all lie within the Colorado Desert. Palm Springs is located approximately at the letter "c" of San Jacinto as printed on the map. The Indio Hills are a few miles east of Palm Springs. The Morongo Pass, north of Palm Springs, passes through the San Bernardinos into the Mohave Desert.—This map was furnished through the courtesy of the McGraw-Hill Book Company, and taken from N. M. Fenneman's Physiography of the Western United States.

which are many plants, and over a thousand species of fossil insects. This deposit is assigned to the Lower Miocene, some millions of years later than the Green River formation. Comparing the two, it is at once noted that the Green River rock is denser, so that the beds would be very hard to work were it not that numerous assessment holes had been blasted out by those intending to establish claims for the oil shale, which it is not now profitable to work, but which in case of need would supply an almost inexhaustible quantity of fuel oil. It seems doubtful whether those who have spent their money in this way will get any return, but the student of fossil insects and plants may look over the debris and here and there pick up something of great interest.

Comparing the products of these deposits, we note a striking similarity in the flora, but also a striking resemblance to plants still living. There has not been much evolution of plants during Tertiary time, except as regards species and perhaps subgenera. It must be said, however, that the fossil-beds exhibit a flora more like that of the southeastern states than that of the present Rocky Mountain region. Some of the plants appear to belong to the family Proteaceæ, now extinct in North America but abundant in the southern hemisphere.

In spite of resemblances noted, there are many differences, and the long period of time between the deposits is indicated by the fact that the very numerous insects seem to be all different, and the representation of families and genera is often not at all the same. At Florissant there is more evidence of immigration from the Old World, as shown, for instance, by the presence of several kinds of tsetse flies.

The point which is essential for the present discussion is that as late as the Lower Miocene, localities which are now at about 8,000 feet in altitude were evidently much lower; sufficiently low to have a warm temperate climate without frost. No palms occur at Florissant, though fossil palms are known from the upper Cretaceous of Colorado.

The Elevation of the Range

Blackwelder[4] puts the case in words which cannot be improved:

> The present existence of the Colorado River is due solely to the fact that the Rocky mountains of Colorado, Wyoming, and Utah are sufficiently high to condense moisture from winds that would otherwise yield little rain or snow. For the most part, the ranges that cause such precipitation are more than 10,000 feet high. If the Rocky Mountains could be reduced to elevations of only 5,000-8,000 feet, this power would be largely lost, and there would be no excess of water to form such a river as the Colorado, and the

region would probably become a land of separate enclosed basins like Nevada and western Utah. If one concedes, therefore, the implication of much historical evidence that the Southwest, including the central and southern Rocky Mountains, was in late Tertiary time lower in altitude and distinctly more arid than now, he must logically suppose that it had no large river such as the Colorado, but that its main features were broad undrained basins and low mountains.

Blackwelder goes on to say: "There is ample evidence, noted by many writers on the region that uplift amounting to thousands of feet—perhaps as much as 6,000 feet in the Central Rocky Mountain region—did occur sometime during or after the Pliocene period." That is, this period of elevation was evidently later than the formation of the volcanic shales, so rich in fossils at Florissant, and very much later than the Green River beds.

Axelrod[5] says: "This trend toward aridity in Western North America, which has been almost continuous since the beginning of the Tertiary, seems to have culminated in the Lower Pliocene. The arid southern flora expanded to the greatest extent at that time and in northern areas replaced certain of the older and more mesic Miocene genera of northern origin. This appears to have been due chiefly to a greater degree of aridity rather than to a complete absence of summer rainfall."

H. D. MacGinitie, who is revising the Florissant flora, writes (in litt.) that "this flora is a mixture of two elements, the stream side and lakeside, and there is a considerable group of plants (*Bursera, Mahonia, Vanquellinia, Quercus, Rhus, Prosopis, Ailanthus, Petraea, Cercocarpus, Dodonaea, Ephedra, Pinus, Rhamnus, Thouinia, Trichilia,* etc.) which grew in a southern climate with dry air and probably brilliant sunshine."

In Axelrod's Miocene (Tehachapi) flora of the western border of the Mohave desert, of the genera just cited, the following are included: *Pinus, Quercus, Mahonia, Cercocarpus, Bursera, Rhus, Dodonaea* and *Rhamnus,* but no species are identical except two or three which are doubtful. Axelrod has one palm, assigned to the genus *Sabal,* closely related to a Mexican species.

All this evidence seems to indicate that the erosion due to the Colorado River and its tributaries, enormous as it is, is in fact a thing of quite recent times in a geological sense. It is thought by Blackwelder to have begun some time during or after the Pliocene period, and in fact it is continuing today. The Colorado River in the Grand Canyon looks like soup, and as some humorist described it, is "too thick to drink and too thin to plow."

James W. Moffett[6] describes how the formation of artificial

Lake Mead by the Boulder Dam has resulted in the interception of most of the silt carried by the river, and records seven species of fish which are now able to live in the river.

The Grand Canyon of Arizona

Although the Colorado River derives its water from the elevated range to the east, causing the precipitation of rain and snow, it does not follow that such precipitation occurred in the lower part of the river, in what is now Arizona. On the contrary, the aridity of that region facilitated the excavation of the Canyon. As throwing light on the age of the Canyon, some facts of animal and plant distribution may be considered, but it must be remembered that the north rim is much higher than the south, so that its climate differs on that account. It appears that the common large snail of the Rocky Mountains, *Oreohelix strigosa depressa,* has reached the northern rim, but has never been able to get across the Canyon. A short distance from the Bright Angel trail, on the southern side, I found subfossil shells of a quite different species of *Oreohelix,* representing a new variety. Professor J. Henderson described a supposed new snail said to be from the Grand Canyon, collected by E. Bethel; but it turned out to be a California snail, mistakenly labelled as coming from the Grand Canyon.

The extraordinary Kaibab squirrel (*Sciurus kaibabensis*) with a white tail, occupies the north rim of the canyon, but has not got across. It probably would not find the lower southern rim so much to its liking. This squirred, in all characteristics save color, closely resembles *S. aberti* of the Rocky Mountains, a species associated with the yellow pine. Mr. L. W. Klauber tells me the Grand Canyon has one endemic reptile, the rattlesnake *Crotalus viridis abyssus,* which seems to be sufficiently divergent to be considered a distinct subspecies. With regard to the Canyon as a barrier to reptiles, Mr. Klauber (litt., Jan. 1945) makes some very interesting observations. "The north rim is so high that it acts as a barrier to much of the reptile life, although the Lower Sonoran forms found in southwestern Utah do have access to the Canyon by way of Kanab Creek. The Lower Sonoran forms which are now found in the Canyon may have come in by this route, or they may have come up the river from the west. In any case, there are some forms found in the Canyon which have not been taken on either rim. However, it must be admitted that the total amount of collecting which has been done in the vicinity is small compared to that around the Salton Sea and therefore the

answers to these problems are, as yet, imperfectly known; but in general I think it may be said that the Canyon is a definite barrier to reptile life, not particularly because it is a canyon which is both very wide and deep, but because it interposes a high plateau area not suitable to the Lower Sonoran forms of southern and western Arizona or southwestern Utah. We might have the same effect if a mountain range was interposed, and such is in fact the case with regard to the mountains of central Arizona. I do think that the Colorado River with the Canyon interposes a much more serious barrier to the crossing of wild life than the river after it leaves the Canyon, for within the Canyon it must change its course rather infrequently and is a swift and dangerous stream, whereas out on the desert it is wider and slower, and changes its course rather often, must have had peninsulas which were first on one side of the river and then on the other, thus transferring animals. However, even today in the Yuma area there are one or two reptile species not uncommon on the Arizona side which apparently have not yet succeeded in crossing." With regard to the last point, it may be added that Grinnell[7] lists several kinds of rodents to which the lower Colorado River acts as an absolute barrier. These are *Ammospermophilus harrisi, Thomomys chrysonotus* and *Perognathus intermedius* living on the Arizona side; *Ammospermophilus leucurus, Peromyscus crinitus stephensi, Thomomys albatus, Perognathus formosus* and *P. spinatus* on the California side. There are also species of *Citellus, Dipodomys,* and *Perognathus* which occur on both sides but show slight, almost impalpable, differences on the two sides.

Although Arizona is so extremely rich in species of cacti there is no cactus confined to the Grand Canyon.

The Formation of the Colorado Desert

Looking at the Grand Canyon, one might have supposed it to have been due to some great terrestrial convulsion, but it is well known that it owes its origin to erosion by water. What has become of the vast quantity of material thus removed? Some of it, no doubt, was eventually deposited in the Gulf of Mexico, but by far the greatest amount was deposited on or about the lower part of the Colorado River and thus was built up the accumulation of gravels and sands, which make the Colorado Desert. Borings, some 1,000 feet deep, have penetrated the alluvial clays, sands, and gravels without reaching bedrock.

Some recent papers attribute this great deposit to erosion from

the adjacent mountains, but it is impossible to imagine what can have become of all the material brought down by the Colorado than its deposition as just postulated. It is of course true that much material has been derived from the mountains; the finest and largest alluvial fan I ever saw is on the east side of San Jacinto Mountain, a short distance north of Palm Springs. But the detritus from the Colorado River contains many fragments of the red Upper Carboniferous (Pennsylvanian) rock of the Grand Canyon, as I am informed by Mr. K. B. Garner. There is a report of fragments of crinoid stems, said to have been derived from the upper part of the Colorado River, but I understand that crinoid fragments might have been derived from the nearby mountains. Dr. J. P. Buwalda writes (litt., Dec. 6, 1944) "In the gravels around Yuma and Needles one can recognize many of the formations well exposed in the Grand Canyon. At the present time much of the Colorado Desert, in the Coachella Valley, is considerably below sea level, the lowest point being about 286 feet below." I asked Dr. Bailey Willis how this could have come about, suggesting the great load of silt as a possible cause. His reply (litt. Oct. 20, 1944) is so interesting that I quote the whole of it:

> In this question you bring up an old problem, whether the hen or the egg came first. The subsidence of troughs like that in which the Colorado delta has been built up has been attributed by eminent geologists either to the load imposed upon the foundations or to the subsidence of the foundations. I, myself, think the two causes cooperate, the primary one being subsidence and the secondary one being the load. The foundations of terra firma are by no means everywhere stable, and consequently a given load may or may not aid subsidence. Where it does, and I think that is the condition under the Colorado delta, I surmise that there remains down in the depths a molten mass which is a weak foundation and yields by adjustment to the load placed upon it. Were I asked why I think there may be such a molten mass below, I would point to the Tertiary granites and suggest that their roots may still remain melted.
>
> I have in mind an example in the Philippines. The Manila plain, 100 miles in diameter, is subsiding, and all around it are volcanoes, which for the last few hundreds of thousands of years have been giving off gas. That is the case of the cooling body under the surface. In the neighborhood area of the Sibuyan Sea, raised coral reefs bear evidence to the fact of recent uplift which is still in progress. That, I think, is an area underlain by a hot body which is heating up and swelling.

In the Colorado Desert, I visited the "mud pots" near Brawley, where very hot water comes to the surface and lets off steam.

The Gulf of California once extended north to the vicinity of San Gorgonio Pass, but the subsidence took place after the sea had been excluded and the valley filled up with detritus as described; or rather, we may suppose that it occurred while the valley was filling up. There is no evidence that the sea ever returned to its old bed.

THE UNDERLYING MARINE FORMATION

At various points marine shells have been found, testifying to the former extension of the Gulf of California. The most important locality is Coyote or Carrizo Mountain, in Imperial County. A well illustrated account of the fossils from this locality was published by Hanna[8] in 1926. After enumerating the various published opinions regarding the age of the marine beds, from Cretaceous to Pliocene, he says:

"A critical study of the mollusca contained in the various collections I have examined, leads me to agree that the age cannot be greater than Lower Pliocene and I am much inclined to the belief that the greater portion is Middle and Upper Pliocene."

However, Woodring[9], without making a critical study of the fossils, concluded that the beds were of Miocene age, probably late lower Miocene. However, he said: "If the fauna is Miocene, the percentage of mollusks referred by Hanna to species living in the Gulf of California (65 per cent), is much too high." The opinion reached was that, owing to the poor preservation of much of the material, Hanna's determinations were unreliable. But more recently, large collections have been made, particularly by Richard Bramkamp, who did not complete his work on them, and is now in the vicinity of the Persian Gulf. Dr. Woodring writes (litt. Feb. 10, 1945) that Bramkamp published an abstract of his results [*Proceedings of the Geological Society of America* for 1934, page 385 (1935)]. From his locality at the north end of the trough Bramkamp obtained "a large number of small genera and species not found in the strand facies at Carrizo Mountain and nearby." There is a further abstract by L. A. Tarbet and V. H. Holman.[10] They consider the formation Upper Miocene. Woodring himself, now thinks the beds are Middle Miocene or possibly Upper Miocene. He has referred to the matter again in *United States Geological Survey Professional Paper* 190 (1938). Hanna described seven of the species of mollusks as new, and at an early date Conrad described three as new, while Ralph Arnold in 1906 published six new species of Pecten. Vaughan (1917) described all the twelve species of corals as new, but one was later held to be a synonym. Kew describes three echinoids, and C. E. Weaver one.

It would seem very probable that all these fossils are not of the same age, but the thing that now concerns us is the age of the latest, as this is the limiting age for the beginning of the events which led to the formation of the Grand Canyon.

The problem has been rather recently discussed by Buwalda and W. L. Stanton (*Science,* Jan. 24, 1930) and they say that the upper part of the Indio Hills block is constituted of two formations. One of them is marine and is the Carrizo formation of W. S. W. Kew (1914); the other, several thousand feet thick, and consisting entirely of arid-climate terrestrial deposits, is called the Indio formation. "The strongly folded and erosionally beveled Indio formation records a long interval of continental deposition, deformation and degradation between the deposition of the underlying marine Carrizo and the development of the landscape which truncates the Indio and on which the Colorado [River] cone—heretofore regarded as the dam which cut off the sea—was built." The Indio formation, from which no fossils were obtained, is considered not older than Middle Miocene and not younger than Lower Pliocene. Thus, according to these authors; they also hold that the salt in the bottom of Salton Basin was in all probability derived from the evaporation of the Colorado River water, and not from a cut-off arm of the sea.*

The conclusion would then be that the detritus from the Colorado River was not the original cause of the exclusion of the Gulf from the region of the present Colorado Desert and this would still further limit our estimate of the age of the Grand Canyon and the origin of the present desert as we find it. This agrees with the conclusions derived from other data. The fact that the sea did not invade the Colorado Desert during Pleistocene time should be considered by those who postulate great changes in sea level.

Lake Cahuilla (Blake Sea)

During the Pleistocene there were periods of increased precipitation, resulting in the formation of very large lakes in regions previously and subsequently arid. This condition was by no means confined to the region of the Colorado Desert. Hubbs and Miller[11] have given a good summary of the conditions in the Mohave and adjacent areas "The Quaternary Mohave River formed a large body of water over the present playas of Silver and Soda Lakes. This lake, the maximum area of which was about one hundred square miles, was named Lake Mohave by Thompson (1921)." Another body of water, considerably larger, covered the northeastern part of the flat valley east of Daggett. This was called Manix Lake by Buwalda (1914).

*See also William J. Miller, *California Journal of Mines and Geology,* Jan. 1944, vol. 40, p. 67.

In the region of the present Coachella Valley there was a very extensive shallow lake, called Lake Cahuilla† (or Blake Sea), covering an area of 2,200 square miles. This was in late Pleistocene times. Dr. Woodring writes that he thinks the age of Lake Cahuilla is thought to be only a few tens of thousands years. Scattered over the area formerly occupied by this lake, are millions of fresh water shells, representing a small number of species. The species represented are:

Andonta dejecta

Some very good material of this species, in part with the valves still joined, was brought to the Desert Museum by Mrs. J. Russell of Cathedral City. This was first reported as *A. californiensis* of Lea (1870), which was described from the Colorado River in California, but it is evidently the *A. dejecta* of Lewis.

Pisidium, possibly *P. rowelli.* Found at Travertine Rock as reported by J. L. Baily, Jr. (in litt.)

Physa humerosa

Amnicola longiqua

Hydrobia or Tryonia protea

Helisoma tenue

The most abundant species is *Tryonia protea.* Another species, *Tryonia clathrata,* was formerly reported, but it is a native of Nevada, and it appears that the records from California are erroneous. Stearns[12] called attention to the great variability of the *Physa,* while *Tryonia protea,* as its name indicates, has been recognized from the first as one of the most variable of molluscs. All this variability occurs in the same environment, but it may be that the environment in some way induces it, as I have seen a series of extraordinarily variable *Limnaea auricularia* from a lake, probably of the same general character, in central Asia. The smooth form of *Tryonia protea* has been called *seemani* Frauenfeld. This name was originally applied to shells from Michoacan in Mexico, and it is doubted whether they represent the same species. However, Dr. Joshua Baily, Jr. informs me that Dr. Pilsbry told him he could not see any difference in the lots from Michoacan and the Colorado Desert. This fauna is so recent as to be practically Holocene and all the species are still found living in various scattered localities.

In a later paper[13] Stearns mentions that a few marine shells

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†The name *Lake Cahuilla* was proposed by W. P. Blake who first described the Colorado Desert. *National Geographic Magazine,* vol. 18, p. 830 (1907).

have been found in the Lake Cahuilla deposits, namely *Ocinebra poulsoni* and species of *Tagelus* and *Cylichna.* I found a single *Acteocina* in a large collection of *Tryonia protea* brought by Mr. Ross J. McClelland from Fish Spring, Salton Sea. Probably the Cylichna reported by Stearns was *Acteocina.* These few marine shells cannot be taken to indicate marine conditions. They may have been blown by the wind from the shores of the Gulf or they may have come in the excrement of birds. Since this was written, Dr. W. P. Woodring has informed me that he saw specimens of the marine genus *Acteocina* found with *Hydrobia protea* from the Lake Cahuilla deposit, in the hands of Messrs. George Willett and W. H. Holman. I learn from Mr. Willett that the Acteocina is new, and will be described and named by him in the *Bulletin of the Southern California Academy of Science.*

In addition I have received a letter from Dr. Wendell O. Gregg, so full of information that I quote it in full:

I have made a particular study of some of our western Helisomas while supplying living material from this region for Dr. Cram's researches at the National Institute of Health. All material sent to Dr. Cram has been identified by Dr. Morrison. I have also sent specimens of Helisomas directly to Dr. Morrison for identification. Have not in all cases agreed with his decisions but at least it gave me a starting point. As you know our western Helisomas have been a mess. Even identifications by Dr. F. C. Baker received 15 or 20 years ago were anything but helpful.

My set of subfossil Helisomas were received from the Chaces and bore the label "Planorbis ammon Gld., Near Coachella, Calif." There are only four specimens in the set. Two are unusually large specimens of *H. ammon* (Gld). Incidentally I have a small set of fine recent specimens of *ammon* from a pond 5 miles north of Lancaster. This was a storage pond for irrigation water and for several years it has been dry so the colony there is a thing of the past.

A third specimen of *Helisoma* in the set from near Coachella is unquestionably *H. tenue* and I refer it to Baker's *H. tenue californiense.* The only distinction I know between typical *tenue* and *californiense* is that *tenue* is smaller and has narrower and more closely coiled whorls.. Material which I have from Lower California as well as two or three sets from the vicinity of Los Angeles approach typical *H tenue,* as I understand it, although all material submitted to Dr. Morrison for identification including the Lower California material was identified as *H. tenue californiense.* That seems to be our most common form and I have specimens from as far north as Washington.

The other specimen in my set of subfossil Helisomas is definitely the same thing as what Dr. Morrison has identified as the normal form of *Helisoma subcrenatum disjectum* (Cooper). I have taken it alive only from artificial pools and streams in parks. It is also distributed now by dealers in aquatic materials and not uncommonly seen in goldfish bowls. Because of the reddish brown color of the animal it is mistaken for *Planorbis corneus* which is so common in aquaria. I had thought it to be introduced but I later received a set of recent specimens from a remote canyon near Trona. I have examined a specimen from Cooper's original lot of *disjectum* and have concluded that it is probably the same. I am tentatively labeling them *Helisoma disjectum* (Cooper) since the anatomy shows clearly that they have no close

connection with *subcrenatum*. They are more closely allied to the Florida Helisomas of the subgenus *Seminolina*. The finding of this form among the subfossil shells settles the question, whether or not it is introduced.

Many of the specimens of *Acteocina* from the Salton Sea region appeared very fresh, almost recent in appearance. I should think them too fragile to have passed thru the digestive tract of birds. Of course Lake Cahuilla was originally a fresh water body. It is to be assumed that as it dried up it became increasingly saline. Am wondering if, at a time when the salinity of this evaporating lake approached the salinity of the Gulf of Lower California, *Acteocina* could have been introduced into this remnant of Lake Cahuilla in some such way as embedded in mud clinging to the feet of birds or to implements of man. Some of the *Acteocinas* from there appear fresher than the subfossil fresh-water shells with which they were found, suggesting that they existed as living shells after the lake had become too saline for the existence of fresh-water mollusks.

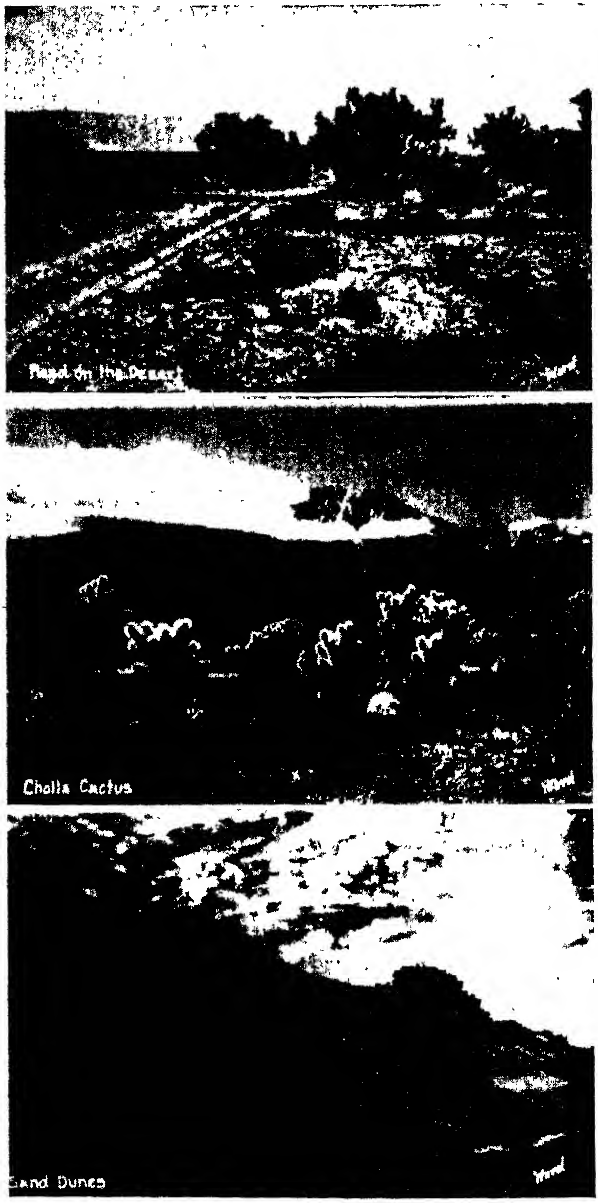
Have you ever found *"Planorbis gracilentus* Gould"? It was described as a white shell from the "great Colorado Desert low lands" and I suspect it was described from subfossil material. I have never seen it.

It is obvious that during these pluvial periods of the late Pleistocene, when so much of the now arid country was covered with water, the climatic conditions must have been different, and at least most of the dry country plants and animals of the present Colorado Desert must have come in since.

How Old Is the Desert?

If we ask this question of deserts in general we must say that they are of vast antiquity. This is proved by the extensive adaptive modifications of the desert biota. Among the deserts I have visited, it seemed to me that those of South Africa might be the most ancient. Here are small plants (Lithops) and grasshoppers looking exactly like stones, giant euphorbias modified to look like cacti. But in the western hemisphere we have plenty of extreme desert types, the most conspicuous being the cacti, with very numerous genera and species, some of them very large. Until recently, there was no direct evidence of the antiquity of the cacti, but Chaney ([14]) has now published a full account of a fossil cactus from the Eocene of Utah. It resembles the living prickly pears, and is named *Eopuntia douglassi*, new genus and species.

It is a striking fact that in the dry region near Mendoza, on the eastern flank of the Andes in Argentina we find representatives of some of our most characteristic desert plants, such as mesquite and creosote bush. In fact, there are good reasons for supposing that these plants originated in the south and are in a sense alien members of our flora. The resemblance is so close that some botanists have considered the plants identical, and it is not very important for the present discussion whether we consider them the same, or only very closely allied. In the case of the mesquite, L. Benson has re-



(Upper) A desert road (left) with the Indio Hills in the background. The shrubs or small trees are creosote bush (larrea) and mesquite (Prosopis). (Middle) The Cholla cactus (Opuntia bigelovii) reaching some four feet in height, growing on the Desert against the background of San Jacinto Mountain.—Ward photo. (Lower) Sand dunes on the Desert, near Palm Springs.—Ward photo.

viewed the matter (*American Journal Botany,* 1941) and gives very good reasons for considering the South American plant a distinct species. In the dry region of Peru, not far from Arequipa, I found an *Encelia* very like our species of the Colorado Desert. Are we to conclude that in some way the desert areas of North and South America have been united, permitting the passage of these genera of plants across the tropical zone? This does not seem possible and it is noteworthy that other forms of life, such as the insects, are different in the two regions. Thus Perdita, the genus of bees so numerously represented in our deserts, gets south to Guatemala, but does not appear at all in South America. I therefore conclude that the plants referred to were probably transplanted as seeds by migratory birds.

When we ask, how old is the Colorado Desert, it must be said that it is very recent in its present form, though there may well have been a desert area in late Tertiary times, as Buwalda suggests, subsequent to the recession of the Gulf.

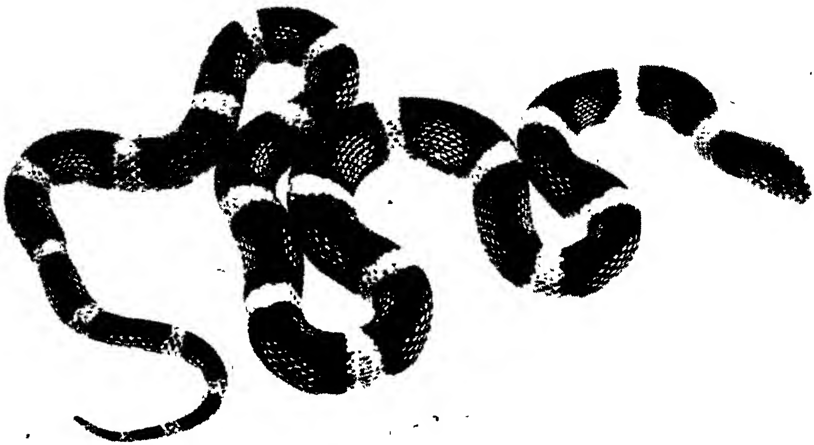
Desert Endemics

By an endemic we mean a species or variety confined to a particular region, and not found elsewhere. There are known two kinds of endemics, (1) those which have developed their peculiarities where we find them, and (2) those which were formerly wide spread, but are now reduced to a small area, and often on the verge of extinction. There are some plants, like the ginkgo and the Franklinia, which have been saved only by being taken into cultivation; they can no longer be found in the wild. The remarkable genus Lyonothamnus, peculiar to the islands off the coast of California, was regarded as a relict endemic, and proof of this has lately been furnished by fossils from two localities on the mainland of California.

It often happens that what appear to be endemic species are really present in other regions, but have been overlooked. A very remarkable arachnid, *Trithyreus pentapeltis,* was discovered years ago at Palm Springs. O. F. Cook, who described it, was so impressed with its characters that he proposed for it a new genus *Hubbardia,* in a new family Hubbardiidae. But Professor Hilton of Pomona College tells me that he has taken exactly the same animal on Santa Catalina Island.

Munz[15] lists what he calls the endemic plants of the Colorado Desert, 48 species. He also lists those said to be endemics of the combined Mohave-Colorado Desert area, 36 species. But of the

first list, 17 extend into Lower California; so do 10 of the second list. Of the first list, one goes east to New Mexico, and of the second, seven are also in Arizona, three in Nevada, and two in Inyo County,



The desert Long-nosed Snake, Rhinocheilus lecontei clarus. A non-poisonous snake whose distribution centers in the Colorado Desert. The body is black, with light bands which are ringed with brick red, or there are red patches on the back. This illustrates the theory of ruptive coloration, as set forth by Thayer and others.—Photograph by Laurence M. Klauber.

California. These plants are not properly endemics, but the following are left as candidates for that position, so far as the data given by Munz indicate, but several of these have been found beyond the limits of California.

Colorado Desert

Cheilanthes parishii (a fern), Andreas Canyon only: apparently a relict endemic.

Selaginella eremophila (Little Clubmoss) Formerly referred to *S. parishii*, but separated as a distinct species by Maxon.

Washingtonia filifera. The Washington palm appears to be a true endemic; there are other forms of the genus in Lower California and Sonora. With it, feeding on the dead palms, is the very remarkable beetle Dinapate wrighti, the largest known species (30 to 52 mm. long) of the family Bostrichidae. Both genus and species are endemic, and the evolution of this beetle is witness to the antiquity of the palms.

Eriogonum nodosum (Knotty Buckwheat).

Aster orcuttii. A very fine species, with large heads, named after C. R. Orcutt (1864-1929) who was a keen student and collector in southern California.

Eriophyllum wallarcei rubellum (Wallace Eriophyllum). The variety rubellum has white-to-reddish flowers, while the typical fern has yellow flowers.

Eriogonum fasiculatum flavoviride. I collected this at Morongo, between the two deserts. It belongs to the Buckwheat group.

Chorizanthe xanti leucotheca (Xantus Spiny-herb).

Dalea californica (California Dalea) a shrub, 2 to 5 ft. high.

Astragalus vaseyi johnstonii (a kind of Loco-weed). Really a mountain plant.

Delphinium parryi subglobosum (Larkspur).
Œnothera bistorta hallii (an evening primrose).
Cuscuta californica papillosa (Dodder).
Gilia pungens hallii (Prickly Gilia).
Eriodictyon trichocalyx lanatum (Wooly Yerba Santa) a shrub, up to four feet tall.
Salvia eremostachya (Santa Rosa Sage).
Lycium parishii (Parish Thornbush) Rare.
Lessingia germanorum tomentosa (Vinegar Weed).
Ditaxis californica (a member of the Spurge family).
Euphorbia eremica (a Spurge).
Mamillaria alversonii (a cactus).
Ammoselinum occidentale (Desert Umbel).
Arctostaphylos glauca eremicola (Desert Manzanita).
Gilia maculata (Pygmy Pink-spot), Rare.
Salvia greatae (Orocopia Sage).
Lycium andersonii deserticola (Narrow-leaved Thornbush).
Brickellia arguta odontolepis (Spear-leaved Brickellia). A rare variety.
Aster cognatus (Mecca Aster).

The Smoke Tree, Dalea spinosa. The common name is obviously derived from its appearance, suggesting smoke. When very young, this plant has broad leaves like ordinary plants but the grown tree appears leafless and very spiny. Its fragrant, dark blue flowers appear in June and July. First discovered by the American explorer, John C. Fremont, it was first described and named by the famous Harvard botanist, Asa Gray, in the early eighteen fifties. The tree is found in the southern Mohave Desert, the Colorado Desert, and its range extends into Arizona and northern Sonora and Lower California.

Halliophytum hallii also appears in this list, as an endemic genus and species, but Kearney and Peebles[16] record it from southwestern Arizona and refer it to the genus Tetracoccus. This is on the authority of Louis C. Wheeler, who contributes the section on Euphorbiaceæ.

It will be noted that 13 of the above have only varietal or subspecific rank.

The Sidewinder, Crotalus cerastes laterorepens Klauber. This rattlesnake, the southern form of the sidewinder, recently described by Klauber, is so called from the fact that although its head points forward, its movements are made by writhing to one side or the other, in contrast to the forward gliding movements of most snakes. Such adaptation is possible only in comparatively open and sandy country. The prevailing color of the sidewinder is practically that of the sand on which it moves, but the animal is nocturnal. This very excellent photograph was made by Laurence M Klauber.

MOHAVE-COLORADO AREA

Cheilanthes viscida (Lip Fern) To Panamints.
Allium fimbriatum (Onion).
Atriplex canescens laciniata (Wingscale). A doubtful race.
Calendrinia ambigua (Desert Pot-herb). To Death Valley Region. Kearney and Peebles list it for Yuma County, Arizona.
Astragalus agninus (Hoary Loco-weed). Listed as endemic, but Kearney and Peebles report it from Arizona and Sonora.
Stillingia paucidentata (Tooth-leaf). Listed as endemic, but it was originally described from Arizona.
Rhus trilobata anisophylla (Desert Square-bush). To Panamints.
Phacelia campanularia (Campanulata Phacelia).
Cryptantha holoptera (Rough-stemmed Forget-me-not). To Panamints. Kearney and Peebles cite it from western Arizona.
Lycium cooperi (Peach-thorn). Listed as endemic, but occurs in Arizona and Utah.
Pentstemon antirrhinoides microphyllus (Bush Pentstemon). To Providence Mts. A shrub with yellow flowers.

It is noteworthy that the lupines, which have such an enormous number of species and races in other parts of California, have no endemic form in the Colorado Desert.

In the Mohave Desert, now set off as a "monument", by the government, over a large area we find the Joshua tree, *Yucca brevifolia,* in abundance. It evidently has occupied this area for a very long time, and it is known that it was eaten by the now extinct ground sloth, Nothrotherium.[17] The Joshua trees come to within a short distance of Morongo Pass, but they have never entered the Colorado Desert as it would seem they might so easily have done. Jaeger says the Joshua tree was formerly more widespread than at present.

Another very conspicuous plant is the so-called Desert Holly, *Atriplex hymenelytra,* so much used for decorations. It occurs in both deserts, and in Utah, Nevada, Arizona, Sonora, and Lower California. It is abundant in places, but curiously local, and we do not see it in the vicinity of Palm Springs.

The restriction of plant ranges is not easy to explain, and may be due to a variety of causes, but it has been shown, especially in Europe, that the constituents of the soil often have a determining influence, different plants having different requirements.[18]

As regards reptiles, Dr. L. M. Klauber writes (litt., Jan. 1945):

> I quite agree with you that the reptile fauna of the Colorado Desert is not of great antiquity. It seems to me that there is much evidence that the population has come in recently, some from the southeast toward Arizona or the desert areas of northeastern Lower California; some from the north, out of the Mohave Desert; and some from the west, crossing through the various mountain passes. Thus the Colorado Desert fauna comprises a number of mixtures which depend for their results upon which of the three influences

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This air view of the Salton Sea, looking northwest, shows the San Jacinto and Santa Rosa Mountains in the background. The muddy stream in the foreground flowing into the Sea is the Alamo River.—Courtesy Spence Air Photos, Los Angeles.

predominates. In some cases, *Rhinocheilus* and *Sonora,* for example, it would appear that the merging of the incoming populations is not yet complete. In some cases the separation and differentiation has been of sufficient extent so that the southeastern and western forms overlap without inbreeding, this being the case with the diamond-back rattlesnakes (*Crotalus atrox* and *C. ruber*), and the gopher snakes *Pituophis.* I know of no form which is endemic to the Colorado Desert.

Very recently[19] Klauber has published a very interesting article on the sidewinder rattlesnake. This animal is so distinct that I think Coues (1875) was quite justified in making it the type of a subgenus *Aschmophrys.* Klauber shows that the typical subspecies is found in the Mohave Desert, and also in Nevada, Utah, and northwestern Arizona. The new subspecies, called *laterorepens,* occurs in the Colorado Desert, and thence to Lower California, Sonora and southwestern Arizona. It might then appear that the two deserts having different subspecies, environmental conditions had been sufficient to favor this differentiation. But it is perhaps more likely that the two forms originated in isolated colonies, one in Nevada, the other in Arizona, and spreading thence, they have met at the boundary between the two deserts.

Among birds, I thought I had a perfectly good endemic subspecies in the Salton Sink Song Sparrow, named *Melospiza melodia saltonis* by Grinnell. This seemed the more probable because *M. melodia* has no less than seventeen subspecies in the west, with limited ranges. But Peterson[20] states that it is much more widely distributed, to south Nevada, southwest Utah and southeast Arizona. In 1938 Van Rossem published a paper ("A Colorado Desert Race of the Summer Tanager." *Trans. San Diego Soc. of Natural History,* Nov. 1938) in which he described *Piranga rubra hueyi,* new subspecies, from Imperial County; but it occurs also in extreme southern Nevada and southwestern Arizona. As the birds from central Arizona and those southwest in Mexico are *P. rubra cooperi,* there is reason to believe that *P. r. hueyi* may have evolved in the Colorado Desert area.

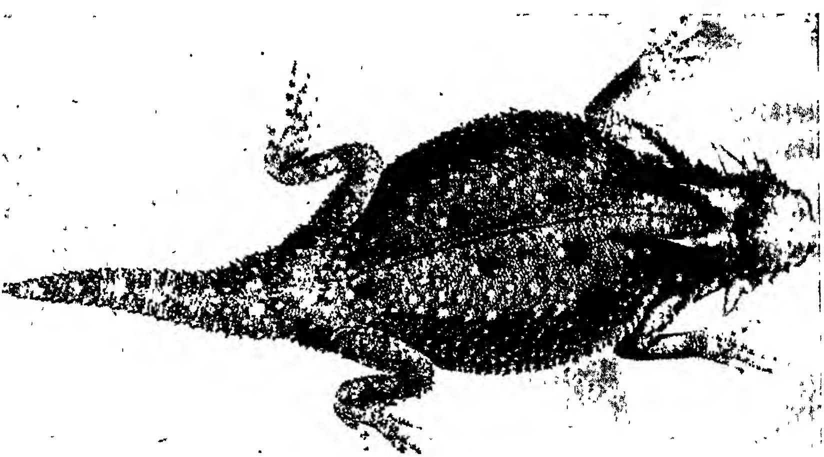
Adaptations

My wife and I, when the hot weather begins in the month of May, shut up the Desert Museum and go to Colorado, not returning until October. But the fauna has to remain where it is, except the migratory birds, and we find various adaptations to the prevailing conditions. In the first place, we note that many creatures sleep or hide by day, and are active at night. The clear skies favor the radiation of heat, and the nights are often cool, though the days are warm. That beautiful little animal, the Ring-tail (*Bassariscus astu-*

tus raptor) sleeps during the day and comes out at night. Hence it was entirely missed by Grinnell and Swarth (1913) in their account of the mammals of San Jacinto Mountain, although as we learn from Mr. Winfield H. Line, it is not uncommon on the mountain. Various rodents are also nocturnal, and likewise a series of reptiles.

Two new genera of parasitic wasps, *Xeroglypta* and *Aulacros,* which are nocturnal, were discovered at Palm Springs (see Mickel and Krombein, *American Midland Naturalist,* 1942). These rare insects may be caught by placing a mason jar up to its mouth in the ground in the proper localities. The wasps, which are wingless in the female sex, fall in and cannot escape.

Very recently, Cowles and Bogert[21] have published a study of the thermal requirements of 18 species of southwestern reptiles, of which six are nocturnal. The two which are active at the lowest temperature are the sidewinder and the little Banded Gecko, *Coleonyx variegatus.* The latter is related to tropical lizards. The one which was active at the highest temperature was the large Chuckawalla lizard, *Sauromalus obesus.* Some of these animals, which burrow in the sand to avoid high temperatures, were studied by Robert C. Stebbins, who in a very remarkable paper (*American Naturalist,* Jan.-Feb. 1943) showed that the nasal passages of the lizard *Uma* were so constructed as to exclude sand grains, while permitting the animals to breathe when under the sand. He found that other genera,



Flat-tailed Horned Lizard, Phrynosoma m'calli Hallowell. This lizard, about 3½ inches in length and ashy gray with brown markings, has its distribution center in the Colorado Desert.—Photograph by Laurence M. Klauber.

Callisaurus, Phrynosoma, Uta, and *Sceloporus,* had similar structures, but the nasal passages in the non-burrowing Iguanidae were quite different.

It has been noted by many naturalists that in desert regions the animals are usually pale colored, resembling the environment. It is usually assumed that this is adaptive, making the animal inconspicuous and so able to elude its natural enemies. Buxton[22] argues strongly against this interpretation, and says: "If we are compelled to disavow our faith in protective coloration as the cause of this remarkable general depigmentation, to what are we to turn for an explanation? The cause is one which affects animals of every type, in every desert; it does not discriminate between prey and captor, between the creeping and flying animals, between the diurnal, the nocturnal, and the subterranean. It is so universal in its application that it is probably physical. No biological agency, such as the struggle with rivals for food or water, the avoiding of enemies, or seeking a mate, can cover so wide a range of animals; heat alone it is not, for heat in other parts of the world does not produce these uniform pale forms; low or fluctuating humidity it can hardly be, for the animals which live below stones and in burrows by day and emerge at night, are not exposed either to very low or very fluctuating humidity. I am unable to suggest any condition or combination of conditions, which can make itself felt so widely, but I feel that the explanation will eventually be found in studying the effect of physical conditions upon the animal life."

Buxton stresses the nocturnal forms, whose pale coloration can hardly be protective at night, and calls attention to certain exceptions to the general rule, especially those intensely black beetles which live on the desert on both sides of the world. With regard to the beetles, they usually have an offensive odor, and their conspicuousness may be considered to facilitate recognition and avoidance by possible predators. We have found that the species of the Tenebrionid genus *Eleodes,* so characteristic of our southwest, when placed in a bottle with a wad of cotton over them, will kill other insects placed in the bottle by their fumes. At the same time, some desert insects, not thus protected, are intensely black. I have found black bees, for instance, in the arid region of Peru. With regard to the bees, it must be said that in general the desert species do have a peculiar pallid appearance, which cannot well be attributed to protective coloration. Thus the bees of the Sudan, extending westward into northern Nigeria, have a peculiar aspect which distinguishes

them from those of the Mediterranean littoral to the north, or the central African regions to the south.

In the Rocky Mountain region there are areas of red soil, on which the horned lizards (*Phrynosoma*) and the grasshoppers are prevailingly red; it is hard to avoid thinking of this as protective coloration.

It would appear that the matter is complex, and as yet not sufficiently understood, but the various explanations do not necessarily exclude one another. If the pallid color is a physical effect due in some way to the environment, it is still possible to suppose that those types which were most susceptible would be the most successful on the desert owing to this inconspicuous coloration.

I have made a list of the races of mammals, occupying the arid regions of southern California, which are characterized by this pale coloration and frequently smaller size:

Scapanus latimanus occultus (Southern California Mole).
Odocoileus hemionus eremicus (Mule Deer).
Ovis canadensis nelsoni (Bighorn Sheep).
Myotis californicus pallidus (Little Pallid Bat).
Procyon lotor californicus (Southwestern Raccoon).
Procyon pallidus (Desert Raccoon). This raccoon may fairly be called a Colorado Desert endemic.
Lutra canadensis sonora (Otter).
Vulpes macrotis macrotis (Long-eared Kit Fox).
Vulpes macrotis arsipus (Desert Kit Fox).
Conis estor (Desert coyote).
Felis oregonensis browni, Lower Colorado River, Arizona (Mountain Lion).
Glaucomys sabrinus californicus (San Bernardino Flying Squirrel). San Bernardino and San Jacinto Mts.
Thomomys perpallidus perpallidus. (Palm Springs Pocket Gopher).
Thomomys perpallidus albatus (White Pocket Gopher).
Perognathus fallax pallidus (Pallid Pocket Mouse).
Dipodomys agilis cabezonae (Cabezon Kangaroo Rat).
Onychomys torridus pulcher (Desert Grasshopper Mouse).
Peromyscus crinitus stephensi (Palm Desert Mouse).
Peromyscus californicus insignis (Southren Parasitic Mouse).
Sigmodon hispidus eremicus (Western Cotton Rat).
Neotoma fuscipes mohavensis (Mohave Desert Wood Rat), Mohave Desert only.
Lepus californicus deserticola (Colorado Desert Black-tailed Jack Rabbit).
Sylvilagus auduboni sanctidiegi (San Diego Cottontail), West of the mountains.

This list is not complete, but it suffices to show how numerous the pallid forms are.

Migration Routes

The floor of the Colorado Desert is occupied by plants which are well illustrated in Jaeger's excellent book,[23] but one has only to leave Palm Springs and go a short distance up the mountain slopes or gulches, and meet with numerous plants which are not treated by Jaeger because not considered to belong to the desert. The true des-

ert plants are related to those of the south, and have apparently come up from Mexico, or in some cases from Arizona. More particularly, they belong to the flora which is characteristic of Lower or Baja California. This long peninsula has, in spite of its general aridity, a very rich flora, strikingly different from that of the Mexican mainland across the Gulf.

One has only to go as far as Ensenada to meet with the remarkable Tiny-leaf Rose, *Rosa minutifolia,* representing a subgenus so distinct that Boulenger and Hurst have treated it as a distinct genus. This rose is found nowhere else in the world than in northern Lower California, but it has a relative of the same subgenus or genus, in the *Rosa stellata* of southern New Mexico and Arizona. These are relict forms and point to the fact that elements of the Mexican flora must have spread into our southwest during Tertiary times. Probably the Lower California element in the Colorado Desert is, at least mainly, of much later origin; I list some of the plants as examples:

Agave deserti (Desert Agave).
Mirabilis tenuiloba (White Four o'Clock).
Lotus haydonii (Pygmy Deer-Weed).
Ayenia compacta (Desert Ayenia). Belongs to a tropical group, and is now considered a form of the widely distributed Ayenia pusilla.
Asclepias albicans (White-stemmed Milkweed).
Salvia vaseyi (Wand Sage).
Haplopappus propinquus (Chaparral Goldenbush).
Chorizanthe corrugata (Wrinkled Spine-flower).
Potentilla saxosa (Rock Five-finger).
Vincetoxicum hastulatum (Spear-leaf). Very rare.
Phacelia pedicellata (Specter Phacelia).
Brickellia arguta (Spear-leaved Brickellia).

On the other hand, the mountain ranges, the San Bernardinos, San Jacinto and Santa Rosa Mountains, have served as a highway for animals and plants coming from the north. A very large form of grizzly bear (*Ursus magister*) formerly got as far down the range as San Diego County, but is now extinct. Grinnell and Swarth (1913), in their discussion of birds and mammals of the San Jacinto area, a large work of 200 pages, deal with the mountain vertebrate fauna at great length. They say: "The Boreal life zone on the San Jacinto Peak is seen to be larger in area than any others of the many mountain masses of Southern California, excepting the San Bernardino Mountains; the number of Boreal types existing upon it exceeds those on any other of the mountains coming into the problem, excepting, again, the San Bernardinos."

For the whole area considered, they list 63 different mammals and 169 birds, but a fair proportion of these may be said to belong

to the desert rather than to the mountain. An interesting fact is that not only have several of the species of oaks come south on the mountains but also their gall-making Cynipidae, about seventeen species, recorded by Kinsey and Weld. In *Indiana University Studies,* 1922, Kinsey reported nine species from the San Jacinto range, apparently all collected by himself. He also reported a new variety of *Diplolepis tuberculatrix* on rose. It is a bright rufous form with little black.

This beautiful snail, Micrarionta orocopia, Willett, (x4) was collected in the Orocopia Mountains, above Los Palmas. Micrarionta is confined to the islands off the coast, in its typical form, but species of the subgenus Eremarionta are characteristic of the mountains in the desert region of southern California.—Photograph by George Willett.

The desert regions, or rather the adjacent mountains, are inhabited by snails of the group called *Eremarionta* by Pilsbry, treated as a subgenus of *Micrarionta,* the typical forms of which live on the islands off the coast. S. S. Berry has recently (1943) set aside some of these species as a new genus *Sonorelix,* on anatomical grounds. Many years ago Yates described the species we call *Micrarionta indionensis,* from Indio, or rather the adjacent Santa Rosa range. Two subspecies of this have been separated, *M. i. wolcottiana* which is common on the slopes back of Palm Springs, and *M. i. cathedralis* from the head of Cathedral Canyon, between Palm Springs and Indio. They are, however, feebly differentiated. The smallest species, with a diameter of 12.1-mm. comes from Thousand Palms, Riverside County, and was named by Berry (1930) *M. millepalmarum.*

The mountains of southern California are the refuge of certain animals belonging to an ancient fauna, and now surviving with difficulty in a few places. The exploring naturalist may always be on

the lookout for such forms, which may be restricted to very small areas. A remarkable example of this sort is the genus of slugs called *Anadenulus*. Long ago, some of these small slugs were collected by Henry Hemphill of San Diego, in the Cuyamaca Mountains, west of that city. He called the species *Anadenus cockerelli*, referring it to an Asiatic genus, but it is now recognized as the only species of a very distinct endemic genus. For about fifty years, no more were found, but Dr. Wendell O. Gregg has recently discovered specimens in Orange County and in three localities in Los Angeles County. The slug when alive is up to 28 mm. long, and is recognized by the tripartite sole (under side) which is dotted with black. Some specimens are nearly black and there are generally two longitudinal stripes on the mantle.

The salamander *Ensatina klauberi* of Dunn probably has a similar distribution. It occurs on the San Jacinto Mountains at 5,500 feet, and goes south to northern Lower California. It is also found in Mill Canyon near Banning.

Plant Associations

Grinnell (1914) in his account of the mammals and birds of the Lower Colorado Valley, recognizes a number of associations, as follows:

River Association
Willow-Cottonwood Association
Tule Association
Arrow-weed (*Pluchea sericea*) Association
Quail-brush (*Atriplex lentiformis*) Association
Mesquite Association
Saltbush (*Atriplex polycarpa*) Association
Creosote bush (*Larrea*) Association
Catclaw (*Acacia greggii*) Association
Saguaro (*Cereus giganteus*) Association
Encelia or Rocky Hills (*Encelia farinosa*) Association

In addition to these, and outside our area, is the Joshua Tree (*Yucca brevifolia*) association, which is interestingly discussed by Jaeger in his book on *Desert Wild Flowers*. The night lizard, *Xantusia vigilis*, is not so completely dependent on the Joshua Tree as Jaeger states, as shown by recent observations of Klauber.

We may take as an example, the mesquite association, adding some account of the insects on the mesquite. Grinnell lists 34 species of birds and nine of mammals, not necessarily having any particular connection with the mesquite, but inhabiting the places where the mesquite grows. The mesquite grows near the river, but not in the strictly desert areas. Grinnell says: "This shrub, or tree, provides both shelter and food, the latter through its fruit and foliage, either

directly or by way of insects. The mesquite serves also as the host of a parasitic plant, a species of mistletoe (*Phoradendron californicum*), which when in blossom is visited by myriads of insects, and which produces an abundant and almost continuous crop of berries. Several of the winter and resident birds of the mesquite association depend almost wholly on these mistletoe berries for their food. Notable among these are: *Phainopepla, Mimus, Oreoscoptes, Planesticus* and *Sialia.*"

There is some question as to the proper name of the mesquite. The original *Prosopis juliflora* is from the West Indies; I was familiar with it in Jamaica. Torrey proposed the name *P. glandulosa* for our American plant, but Standley declares that the two completely intergrade in Mexico. Wooton described a form from Arizona, with pubescent foliage, as *P. velutina.* Then it was proposed to refer all these plants as varieties to the South American *P. chilensis.* This last disposition is certainly untenable, as Benson has shown, and Munz agreed when I saw him after his journey to South America. But L. Benson (1941) has set aside the more western plant, which has glabrous foliage and is distinct from *velutina,* as *torreyana,* treating it as a variety or race of *P. juliflora.* Near El Paso, Texas, the three (*glandulosa, velutina* and *torreyana*) grow together, and it is quite possible that they are really distinct species, the intermediate specimens being hybrids. Experimental cultures may be necessary to determine the facts, but at any rate the form about Palm Springs is *torreyana.* Kearney and Peebles state that *P. velutina* is the more common form in Arizona.

The number of species of insects living in or associated with mesquite is very great. Essig[24] records the following:

Schistocerca shoshone (a locust).
Taeniopoda eques (at bases of mesquite bushes).
Reticulitermes humilis (termites in wood).
Publilia modesta.
Eutettix tenellus.
Icerya rileyi (New Mexico).
Tachardiella fulgens (Arizona).
Aspidiotus candidulus (Arizona).
(The last three are Coccidae. I have not as yet found any Coccidae on mesquite about Palm Springs).
Acrosternum hilaris.
Polycesta velasco.
Chrysobothris debilis.
Chrysobothris exesa.
Chrysobothris mali.
Chrysobothris merkeli.
Chrysobothris octocola.
(These Buprested beetles mine in the wood).
Dendrobiella sericans. Mines dead wood.

Apatides fortis. Mines dead wood.
Megacyllene antennatus. The Round-headed Mesquite Borer.
Schizax senex. A serious pest.
Oncideres trinodatus.
Oncideres pustulatus. The Mesquite Girdler.
Pachybrachys prosopis.
Ægeria prosopis. Larvae in galls.
Mylabris uniformis (*M. prosopis*) In seeds.

Felt[25] lists only one kind of gall on mesquite, that of the midge, Asphondylia prosopidis. This insect was described from New Mexico, but I have found it at Palm Springs.

R. H. Timberlake (Ms.) lists the following species of bees, visiting flowers of mesquite in the Palm Springs region:

Hylaeus asininus
Colletes tucsonensis
Megachile discorhina
Megachile odontostoma
Osmia marginata
Ashmeadiella prosopidis
Halictus hyalinus
Perdita numerata
Perdita exclamans
Perdita atramentata
Perdita ten new species

To this list of flower visitors may be added two little wasps recorded by Pate (1939): *Ammoplanops cressoni, Ammoplanops ashmeadi.*

The Wild Bees

Mr. P. H. Timberlake has, in the course of years of collecting, taken 435 species of bees at Riverside, California. This is certainly the largest number taken in any one locality in the world, and the list must be nearly complete. From Palm Springs and the vicinity, about 50 miles from Riverside, Timberlake knows 215 species, but it is probable that 100 more remain to be collected. But the extraordinary thing is, that of the known Palm Springs bees, only 63 occur at Riverside. The greatest number (27) found on any species of flower is on the creosote bush, *Larrea.* The following contrasts between the two lists are striking:

	Riverside	Palm Springs	Common to both lists
Colletes	13	6 (4 new)	1
Sphecodes	26	1*	1
Andrena	45	12 (5 new)	8
Perdita	18	32 (27 new)	1
Osmia	26	5	2
Nomada	28	2	2
Triepeolus	13	0	0
Exomalopsis	2	5 (all new)	0
Tetralonia	9	1 (new)	0
Melissodes	18	2 (one new)	0
Hemisia	1	4	1
Bombus	6	2	2

*When this list was made out no Sphecodes was known from Palm Springs, but on April 6, 1945, Timberlake took there *S. sophiae,* at flowers of *Cryptantha barbigera.*

The combined lists include 61 genera. The total number of new species (to be published by Timberlake) from Palm Springs and vicinity is 67. Many of the described Palm Springs species go east-

ward to New Mexico; for example, *Hylaeus asininus, H. wootoni, Colletes salicicola, Megachile chilopsidis, Heteranthidium larreae, Hoplitis biscutellae, Ashmeadiella bigeloviae, A. prospidis, A. opuntiae, A. cactorum, Andrena mimetica, A. prunorum, Perdita exclamans, Halictus sisymbrii, H. amicus,* etc. Others are known from Lower California.

The diversity in the insect fauna of different parts of Califonia, even when they are not far apart, is remarkable, and is connected with differences in the flora, and in altitude. The number of species is also remarkable. Robertson, who collected intensively in the region about Carlinville, Illinois, got only 297 species, and no other locality in eastern North America has I think approached this number.

From Morongo, between the Mohave and Colorado deserts, I recorded (*Am. Mus. Novitates,* 1937) fifteen species, of which eight have not yet been found at Palm Springs. Timberlake has taken other species at Morongo.

Climate*

Although arid conditions continue from the Colorado Desert eastward through Arizona, New Mexico and part of Texas, there is this important difference: Arizona and the regions eastward have summer rains, whereas the summers in the Colorado Desert and southern California generally, at low levels, are practically rainless. This difference affects the life of these regions, although such plants as the creosote bush and the mesquite extend right across the arid belt. At Indio (Riverside County), 20 feet below sea level, no measurable rain fell from November, 1893 to January, 1895, a period of more than a year.

The average rainfall, in inches, of some stations in our area, is as follows:

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Palm Springs (584 ft.)	0.83	1.20	0.49	0.18	0.07	0.00	0.08	0.23	0.12	0.29	0.28	1.03
Indio (—20 ft.)	0.75	0.45	0.29	0.11	0.05	0.01	0.05	0.22	0.21	0.18	0.18	0.50
Mecca (185 ft.)	0.56	0.35	0.30	0.15	0.05	0.00	0.08	0.43	0.21	0.23	0.20	0.71

	Annual
Palm Springs	4.80
Indio	3.00
Mecca	3.27

With regard to temperature, it is stated that "the region extending from Los Angeles to San Diego has one of the most equable climates in the United States. The summers are rainless and moderately warm. The winters are mild with occasional storms but some sunshine is received almost every day." Catalina Island is said to have only about ten degrees difference in temperature between the

*Based on *Climatic Summary of the United States,* Section 18. Southern California and Owens Valley. U. S. Weather Bureau.26

averages for summer and winter. In contrast with this, the temperatures in the Colorado Desert are as follows:

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Palm Springs	55.2	58.2	63.9	70.5	76.9	86.2	92.7	90.5	84.3	74.7	64.1	54.9
Indio	53.7	59.2	64.9	72.1	79.0	87.8	93.3	92.0	85.8	75.1	63.0	55.4
Mecca	52.5	57.8	63.0	69.9	76.8	85.1	90.8	89.5	83.6	72.5	61.4	53.1

	Annual
Palm Springs	72.7
Indio	73.4
Mecca	71.3

The average maximum temperature at Palm Springs in the summer is:

June—102.3 July—107.4 August—105.4

Listing the biota of the western side of the Colorado Desert, about Palm Springs, we have to distinguish between those species which occupy the face of the desert throughout the years and those which live in the canyons, such as Andreas Canyon, where there is running water all the year, or the dry washes, where there is water underground. It is in these moister spots that many species are able to survive, and such plants as the smoke tree (*Dalea spinosa*) and mesquite, which we think of as typically associated with the desert, grow. There are no desert orchids, but in Andreas Canyon, in April, 1945, Lt. Milton B. Irvine found the beautiful orchid *Epipactis gigantea.* It is interesting to find that a plant so alien to the desert can be found so near to the desert edge, favored by moisture and shade. Munz says of the *Epipactis* "occasional on deserts", but it is obviously not a desert plant and is omitted by Jaeger in his book on the plants of the desert. There are twelve species of terrestrial orchids in southern California.

A date orchard in the Desert near Cathedral City, south of Palm Springs. The clusters of dates (with one exception) on the nearest tree are encased with sack-like coverings to protect the fruit from injury as it ripens. Date-growing constitutes the most important agricultural pursuit on the Desert, save in the highly irrigated districts of the Imperial Valley.

The People of the Colorado Desert*

Mr. M. R. Harrington states that evidence is accumulating that man reached what is now the southern California Desert in the pluvial period that accompanied the melting of the glaciers, at the close of the Pleistocene, perhaps 15,000 or more years ago. The Rancho La Brea fossils are earlier, and so far as we know, man was not present when that deposit was formed. The tar has continued to flow until the present day, and small animals are still occasionally entrapped. Parts of a human skeleton were found at a depth of 6 to 9 feet but are believed to be of later date than the deposit of fossils. However the remains of the large extinct condor-like bird *Teratornis* were found above some of the human remains. It may be that the birds survived longer than most of the creatures now extinct. The California condor (*Gymnogyps*), though much restricted in its range, has survived to the present day.

Near the Salton Sea it is reported that an Indian pictograph was found, covered by a travertine deposit. This has been supposed to indicate great antiquity, but Mr. Harrington states that it may well be not more than a few hundred years old. When I lived in Jamaica I was given some apparently fossil leaves, in a travertine deposit. They could have passed as genuine fossils, had we not noticed that they were mango leaves; the mango being of course an importation of comparatively recent times.

Of present day Indians, the Cahuilles, according to Mr. Harrington, are now about 750 persons, of whom less than 100 live on the reservation at Palm Springs. At one time they probably numbered 2,500.

Mr. Harrington writes:

> Quite a few of the Cahuillas are scattered about through southern California among the general population, but the majority still reside on a number of small reservations in their old territory of which Palm Springs is only one. Others are living with the Serrano on the Morongo Reservation and with the Luiseño—at Pala, for example.
>
> The Cahuilla also made—and still sometimes make—coiled baskets of superior quality. Differing from most Indians they actually dig wells on occasion. The women gathered mesquite beans, pine nuts and other seeds, and these with game brought in by the men formed their chief support.

Other Indian tribes have occupied parts of the Colorado Desert

*I am greatly indebted to Mr. M. R. Harrington, of the Southwest Museum of Los Angeles, for information. The Southwest Museum has published in their journal *The Masterkey*, November 1943, an article on the Indians of Southern California. Several years ago Miss Margaret Boynton interviewed Francisco Patencio, the old and blind chief of the Cahuillas, and wrote a very interesting book of 132 pages, published in 1943. The first part gives the legends of the tribe, the second, the personal recollections of Patencio. Lloyd Mason Smith, when he was curator of the Desert Museum wrote a very excellnt account of the Cahuilla Indians for the local newspaper, and this was republished and circulated by the Museum.

region; the Digueno and Kamia to the south; the Mohave and Yuma and their relatives on the Colorado River; the Serrano to the north; the Chemehuevi to the north and east. The Cahuillas belong to the Shoshonean linguistic stock, related to the Gabrielino, Cupeno, Luiseno and some other Californian groups, the Paiute and Shoshone in Nevada, and to some other tribes; more remotely to the Aztecs of Mexico. They probably came originally from the north. In the Desert Museum are two very large ollas, made long ago by the Cahuillas. In their rounded form and small aperture with a short neck they have exactly the shape of the mud nests of the potter wasp, Eumenes, common in the region. It has been suggested that the ollas were modeled after the little pots of the wasps, but this seems improbable. Edwin F. Walker thus describes the pottery: "Pottery was made by the women out of desert clays tempered with sand. The paddle-and-anvil method was usually followed. In rare cases the pottery was decorated, usually with dot, line, and triangle designs in red. The forms included round cooking bowls (some very large), cooking pots, food bowls (both round and oval), dippers, ceremonial bowls, great storage jars, and water bottles or ollas from small to large in a wide range of rounded and oval forms. Most of the pottery was very symmetrical and well made, the ollas being very thin. The pottery was fired to an extreme hardness in an open fire pit utilized as a kiln."

Francisco Patencio, as quoted by Miss Boynton, says: "The thing most used in the women's work was the stone mortar. This was made of solid round rock that was hollowed in the top—called mortar in English, can bajol in Indian; the pestle, English, and pa ol in Indian. A hole was pounded out in the center, which became deep enough for grinding meal, hulling grain seeds and nuts. A long slim rock was used to do the pounding and grinding. These mortars are sometimes made, many of them, in a solid ledge, such as can be seen in the Andreas Canyon at the cliffs, or Snow Creek."

The men went hunting "to get a rabbit skin, to wrap the baby bunting in", as the nursery rhyme has it. If the people arrived during the pluvial period, when Lake Cahuilla was still in existence it might be expected that evidence of human occupation would be found among the millions of shells left by the lake. It seems that a more careful investigation of these shell deposits may yield evidence of great interest, whether or not any human remains or objects are discovered.

THE SALTON SEA

I cannot now enter upon a lengthy discussion of the Salton Sea, but the subject cannot be omitted in a discussion of the Colorado Desert. In 1905 the Colorado River left its channel, and flooded the Salton Sink to a maximum depth of 70 feet with a surface area of about 330,000 acres. James (*Wonders of the Colorado Desert*) writing in October, 1906, described the Salton Sea as being nearly 50 miles long, and in places 20 miles broad. A large and important work on the Salton Sea was published in 1914 by the Carnegie Institution of Washington, edited by D. T. MacDougal, with chapters by W. P. Blake, Godfrey Sykes, E. E. Free, W. H. Ross, G. J. Pierce, M. A. Brannon, J. Claude Jones, S. B. Parish (on the flora) and D. T. MacDougal. Important papers have lately appeared in *California Fish and Game,* as follows:

George A. Coleman. A Biological Survey of Salton Sea, July, 1929.

William A. Dill and Chester Woodhull. A Game Fish for the Salton Sea, the Tenpounder, Elops affinis, October, 1942.

William A. Dill. The Fishery of the Lower Colorado River, July, 1944.

Dill and Woodhull, writing in 1942, describe the Salton Sea as 40 miles long and 12 miles wide. There is no outlet because of its low elevation. "It is fed mainly by the muddy Alamo and New Rivers, which are simply drainage channels for waste and excess water from the irrigation system of the Imperial Valley. Through these streams and canals it has a connection with the Colorado River. Thus, it is possible for fish to migrate from the river into the Salton Sea, and most of its fishes have been derived in this way." E. H. Glidden, in 1941, reported the fish *Elops affinis* of Regan in the Colorado River, and in May, 1942, this fish was taken in the Salton Sea, where it is now well established. In 1929 the following species of fish were reported to have occured in the Salton Sea:

Cyprinus carpio. The common carp. Formerly abundant.

Gila elegans. Bony-tail.

Xyrauchen texanus. Humpback Sucker. The name of this fish is unfortunate, as it does not occur in Texas, any more than the Colaptes cafer inhabits Caffraria.

Salmo pleuriticus. Colorado River trout.

Mugil cephalus. Common mullet. Abundant.

Cyprinodon macularius. Desert Cyprinodont.

Coleman says: "The carp disappeared several years ago in what seemed to be an epidemic. The mullet have also almost disappeared. The humpback sucker is rather common. The *Cyprinodon* was abundant and thriving. An addition to the list was found, *Gambusia affinis,* a small viviparous minnow."

Coleman says the Salton Sea is a real sea, the waters comparable to the open ocean in salinity. John Hilton, writing in 1945, describes the mullet as abounding.

The most interesting problem at the present time concerns the barnacles. I have specimens of the barnacles, brought to me by Mrs. Harold A. Pangborn, but I have no facilities for determining the species. They seem to have been brought in in the course of operations of the navy, and are now excessively abundant. John Hilton has published a popular illustrated article on the barnacles in *Desert Magazine,* March, 1945, p. 4. He refers to Sam Hinton's visit to the locality to study the barnacles. Mr. Hinton has kindly sent me the following information:

> Dr. Martin Johnson and I have made but one trip to the locality, but it was intensely interesting. Barnacles now seem to outnumber all other forms of life, both vertebrate and invertebrate. found in the Salton Sea. How they were introduced is a problem; my guess is that a mooring buoy or even a stout rope may have been transported by air, carrying adults. The people who live about the Sea report the first barnacles to have been large and pink (very similar to *Balanus tintinnabulum californicum*); then they found pink ones together with numerous small white ones, and now the pink ones have disappeared completely. The little white ones do not differ from the large pink ones in any way except form and color, and my guess is that the former are simply dwarfed (though fertile) forms of the latter, appearing because of chemical differences (?) between the Salton Sea and their former environment. This is partly borne out by the fact that the multitudinous larvae are of one kind, and at least superficially like those of *B. tintinnabulum.*
>
> Some larvae collected by Dr. Johnson have been reared to apparently adult forms, but in his aquaria have not exceeded a few millimeters in length. (litt. Jan. 1945).

There is evidently a most interesting biological problem involved, and we shall welcome the detailed report which will be forthcoming later.

Dr. W. P. Woodring writes that Mr. W. H. Holman showed him material dredged from the Salton Sea. "It included several genera of Foraminifera that evidently are living there."

Dr. Joshua Baily writes that, according to Henderson, the type locality of the freshwater snail *Helisoma ammon* is now beneath the Salton Sea. He adds that *Helisoma subcrenatum* has been introduced in the Coachella Valley; he saw it in an artificial pool at one of the date farms in Indio.

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THE LAST LECTURE*

Our course is run, our harvest garnered in,
And taking stock of what we have, we note how life,
This strange, mysterious life which now we hold and now eludes our
        grasp,
Is governed still by natural law, and its events
Tread on each other's heels, each one compelled to follow where the
        first has led.
Noting all this, and judging by the past,
We form our plans, until we know at last
    The treasure in the future's lap.

The man, the plant, the beast, must all obey this law,
Since in the early dawn of this old world
The law was given, and the stuff was made
Which still alone can hold the breath of life:
Whereby we know that grass and man are kin,
The bond a common substance which within
    Controls their growth.

Can we know all? Nay, but the major part
Of all that is must still elude our grasp,
For life transcends itself, and slowly noting what it is,
Gathers but fragments from the stream of time.
    Thus what we teach is only partly true.
    Not knowing all, we act as if we knew,
        Compelled to act or die.

Yet as we grow in wisdom and in skill
The upward path is steeper and each step
Comes nigher unto heaven, piercing the clouds
Which heretofore have hid the stars from view.
    The new-gained knowledge seems to fill the air,
    It seems to us the soul of truth is there.
        Our quest is won.

Bold climber, all that thou hast won
Lies still in shadow of the peaks above;
Yet in the morning hour the sun
Rewards thy work of love,
Resting a moment on thy lesser height,
Piercing the vault with rays too bright to face,
Strengthens thy soul and gives thee ample might
        To serve thy human race.

—T. D. A. Cockerell.

*From Professor Cockerell's text book *Zoology*, by permission of the publishers, The World Book Company, Yonkers, New York.

The Editor's Page

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ROBERT TAFT, *Editor*

The world has greatly changed since our last issue appeared three months ago. With shocking suddenness came the first of the major changes of recent months, the death of President Franklin D. Roosevelt. Elected by the will of the majority, he was for many years, according to the democratic principles which we profess, the leader of us all. Not only our leader in domestic affairs but a leader, acknowledged the world over, of free peoples. In this last respect his loss, as we see it now, is most calamitous. Less than a month after the President's death, Germany collapsed. That event, so eagerly awaited, yet so dearly bought, brings immediate need of all the wisdom, experience and patience that we and our allies possess in planning our own future and that of our vanquished enemies.

To the editor, these problems seem more difficult and more nearly insoluble than the other major task remaining before us—the defeat of Japan. If one can predict the future at all, Japan's defeat appears inevitable once the full power of our terrible might is brought to bear upon her; the question is not of Japan's defeat but of the time necessary to accomplish that defeat. One can but hope that there are methods, still unrevealed, that will shorten the time when this desired end is reached.

Even when the final end is reached our joy should be tempered with the remembrance of the fact that we ourselves are partly to blame for the suffering, desolation, anguish and wholesale death that has been the central theme of our lives in the years just past. All of us who have lived any part of our adult lives between the two world wars should feel this sense of guilt—if we have any judgment left at all. If we had made sufficient effort to be wiser, more intelligent, more active, and less selfish, the world conflagration would never have developed or, at least, could have been extinguished in its early stages. Will we ever learn from our experiences of the past?

This issue of the *Transactions* might well be called "The Cockerell Number." Not only has Professor Cockerell, an honorary member of the Academy since 1908, contributed the splendid leading article for this issue but on page 40 will be found one of his poems "The Last Lecture". In addition, there will be found at the end of the editor's section a quotation from one of Dr. Cockerell's essays.

Although born in England he has, with the exception of three years, been a resident in our

DR. AND MRS. T. D. A. COCKERELL

great Southwest for well over half a century. It is doubtful if there are many biologists living who have a broader knowledge of the flora and fauna of this region than has he. But Professor Cockerell is no stay-at-home. He has been a member of many scientific expeditions that have taken him around the world. In this manner Siberia, Russia, Japan, South America, the Madeira Islands, Australia, Morocco, and central and south Africa have been visited.

His scientific work has been exceedingly extensive, for, not only is he an indefatigable worker in the field and in the laboratory, but he has been a prolific writer on scientific subjects. Over three thousand of his notes and articles have appeared in the scientific press. At least one of these, "Life and Habits of Bumblebees", was regarded as so excellent an example of expository writing that it was included in a book of essays for study by college classes in composition.

Professor Cockerell is also the author of three books: a widely used textbook, *Zoology,* first published in 1920, a work, *Zoology of Colorado,* published by the University of Colorado, and a third book, *The Bees of Africa,* published by the British Museum. The editor, now being some thirty years removed from his college zoology, is no judge of the merits of Dr. Cockerell's *Zoology* as a text but he was struck by one outstanding fact concerning this book. The social meaning and implications of the principles of zoology are continually stressed, a method of textbook writing that is notable by its absence in the textbooks of the exact sciences. Frequently these latter texts are dry, humorless and completely centered on subject matter; to read them one would secure no knowledge—save for brief mention of certain applications of subject matter—of the impact that the subject un-

der consideration has made on human progress and civilization, and especially on its mode of thought. The rather obvious conclusion to be made concerning the writers of such textbooks is that they neither know nor care about such matters.

But the subject of this editorial is Dr. Cockerell and not textbook writing so we must return to his career. Professor Cockerell's life work was determined in early childhood by an innate interest in natural history. This interest, Dr. Cockerell writes, began "as an emotional rather than an intellectual exercise, and even today the love of beauty of form and color and motion, is an important part of all the pleasure I take in living things." Encouraged by his father and friends, he rapidly acquired a knowledge of natural history so that even as a child he was almost a professional; as a boy of twelve, for example, he made a discovery (that of "caterpillars of the finest of Madeiran butterflies") which was reported in a scientific work.

In 1887, Professor Cockerell developed a mild case of tuberculosis and was advised to go to the mountains of Colorado to regain his health. During a three years' stay in Colorado he devised a curriculum for his own study in entomology, botany and zoology and set before himself the ambitious task of cataloguing the entire fauna and flora of Colorado, recent and fossil. After three years in Colorado he returned to England apparently cured and with a wealth of self-acquired knowledge. A year's work in the British Museum of Natural History and two years as director of the Kingston (Jamaica) Public Museum again brought on tubercular symptoms and he returned to southwestern United States in 1893. There then followed a career of museum work, of professional entomology and of teaching in New Mexico and in Colorado. In 1906 he went to the University of Colorado where, as a member of the zoology department, he remained until his retirement as professor of zoology in 1935.

After his retirement, Professor and Mrs. Cockerell began spending their winters in California; in recent years at Palm Springs, on the Colorado Desert. Palm Springs possessed a small local museum and, because the curator went into the Military Hospital, also at Palm Springs, as technician, the Cockerells volunteered to take charge of this, the Desert Museum, which is a room in the city library and is kept open from the middle of October until the middle of May. It possesses specimens of the fauna and flora of the arid southwest as well as good exhibits illustrating the work of local Indians. Lectures, motion picture studies of animal life and the publication of natural history notes in the local newspaper have attracted large numbers of visitors; over sixteen thousand persons examined the exhibits of the Desert Museum in the season 1944-45.

As has been suggested, Dr. Cockerell's interests in the life sciences are broad and deep and he justly calls himself a naturalist; an unusual profession in these days of specialization and

super-specialization. More extensive details of his long career may be found in a series of ten articles "Recollections of a Naturalist" published in *Bios* beginning with the December, 1935, issue and continuing until October, 1938. The editor has read them all with real interest but three of the essays had special appeal: the first one, which includes Professor Cockerell's philosophy of life and of teaching and one that should merit the attention of all teachers; the ninth, which expresses Professor Cockerell's ideas on verse, a field to which he has also contributed (see the example mentioned above on page 40); and the tenth article "The Red Sunflower." This last essay is a review of the discovery of a plant mutation by Mrs. Cockerell (a biologist in her own right and a former teacher of biology) and the development of this mutation by the Cockerells for use as a garden plant.

Although the editor has never met Professor Cockerell personally, he feels, after some months of correspondence, rather intimately acquainted with him. Kindly, courteous, patient, insistent upon fact, he revealed these qualities to the editor through the medium of many notes and letters written in so minute and precise a hand that recourse to a large hand lens was often necessary in reading them.

He can well be called a remarkable man—remarkable for his past achievements and for the work he is doing now. Professor Cockerell, though well in his seventies, has an active interest in human affairs and pursues with zeal the intellectual life of the scholar. It must be individuals such as he that Dickens, that acute observer of human conduct, had in mind when he wrote: "Father Time is not always a hard parent, and, though he tarries for none of his children, often lays his hand lightly on those who use him well."

* * *

The editor wishes to express his appreciation for the help given him the past year by our retiring president, Dr. L. D. Bushnell, in establishing the quarterly *Transactions*. With no precedent to guide him, Dr. Bushnell conducted a canvass of many Academy members on the subject and finally put the question of quarterly publication up to the Council in a fair and impartial manner. The favorable vote for quarterly issues allowed the editorial board to proceed with the new form and President Bushnell was the first to congratulate us upon our achievement.

Attention should also be directed to Dr. Bushnell's presidential address, which appears in this issue. It is a well-written and readable review of the importance of bacterial action in its many contacts with modern life. The editor recommends the article as reqpired reading for all Academy members.

* * *

Dr. Stene's article on the development of Kansas wildlife conservation policies appearing in our last issue (March, 1945) has met with universal approval and commendation among all Academy members with whom the editor has talked since its ap-

pearance, including a very considerable number of members at our recent annual meeting. Not only have members commented on it, but we have had very favorable comment from others both in the state and out, including members of the forestry, fish and game commission, other state officials and other commissions from nearby states. Among the first to write us about the article was Warden Doze of the Kansas Commission, who served from 1923-1929. Warden Doze is now Mr. Burt Doze, editorial executive of the *Wichita Eagle*. Mr. Doze comments that he regards as one of his crowning efforts for Kansas wildlife conservation "the discovery of Lee Larrabee away out in the sand and sagebrush." Mr. Doze in writing the editor also pays tribute to Governor Ben Paulen who gave Mr. Doze his powerful support in securing the initial legislation which started the state lake building program and which created the first fish and game commission in 1927.

* * *

Several inquiries from Academy members have come in concerning the quotation from Professor Conklin's essay "Science and the Faith of the Modern", which was published in the March issue (page 324). The original essay will be found in *Scribner's Monthly,* November, 1925. Professor Conklin, one of our most illustrious men of science and now emeritus professor of zoology at Princeton University, very graciously permitted the use of the quotation and further stated "Indeed, I am honored by your request, and if I may judge by the number of such requests I have received, this article is one of the most effective that I ever wrote." The full meaning of Professor Conklin's judgment becomes clearer when it is recalled that he is the author of well over 150 books and articles, many of them of great professional importance. An interesting biographical sketch of Dr. Conklin by Professor A. Richards will be found in *Bios,* March, 1935.

* * *

Although the editorial board gets little in the way of thanks for its work, there is another group which receives even less thanks. Such individuals are those to whom the editorial board turns for specialized knowledge or for judgment on debatable or obscure points in the preparation of manuscripts for publication. We therefore wish to take this occasion to publicly thank the following group for their help (which in some cases has been quite considerable) in the preparation of the quarterly *Transactions*: Mr. S. D. Flora of the Kansas Weather Bureau; Dr. Claude Hibbard, University of Kansas; Dr. E. W. Woolard of the U. S. Weather Bureau, Washington, D. C.; Dr. M. J. Harbaugh, Kansas State College, Manhattan; Dr. John C. Frye, University of Kansas; Dr. W. D. Bemmels, Ottawa University; Dr. R. H. Beamer, University of Kansas; Dr. A. L. Goodrich, Kansas State College, Manhattan; Dr. H. B. Latimer, University of Kansas; Dr. F. C. Gates, Kansas State College, Manhattan; Mr. S. W. Lohman of the U.S.G.S., Lawrence; Dr. J. M.

Jewett, State Geological Survey; and Dr. W. H. Horr, University of Kansas.

* * *

Dr. M. P. Culver has recently been announced as the new president of Southwestern College, Winfield, succeeding Dr. Charles E. Schofield, resigned. The *Transactions* hereby offers its congratulations to Dr. Culver and wishes for him the best possible success in his administration. Academy members have long recognized the important part that Southwestern College has played in science training in the state and trust that Dr. Culver will make every effort, even in these difficult times, to maintain the high standards of staff and of equipment at the College which have enabled Southwestern to achieve her marked distinction. The editor has often marveled at their steady stream of brilliant students in chemistry which has reached us at the University of Kansas for graduate study. The eyes of Kansas scientists will therefore be focused especially on Southwestern to see if this remarkable achievement of the past can be continued in the future.

Our deepest feelings, those which seem most fundamental in our nature, are emotional. It is impossible adequately to express them in words or at least so difficult that we consider it genius when some writer is able to set forth, with dignity and beauty, those elemental loves and hates, hopes and fears, which are more or less common to all of us. We think of such work as the highest expression of the human mind, yet it is the product of something essentially primitive and prehuman. The characteristic human quality is the intellect, the marvelous power of understanding, the relations between cause and effect, of describing phenomena, of revealing the history of the past, and often seeing far into the future. To what extent are we truly intellectual? It is astonishing to contemplate the discoveries and inventions of say the last hundred years, and realize how small is the number of those who made them. Our modern civilization, our mode of life, our philosophy, have all been made over by a minority so small that counted by votes no politician would give it a moment's attention. These extraordinary people, without political power, without wealth, little understood and often misrepresented, have nevertheless exercised a dictatorship over our affairs from which, whether we like it or not, we cannot escape. That is something essentially and peculiarly human.

—T. D. A. Cockerell, *Bios*, December, 1935.

Scientific News and Notes of Academy Interest

Academy members who prefer to have volume 47 of these *Transactions* (1944-45) in a single volume, rather than the three separate issues of which it was composed, may secure the volume at a cost of $1.00 postpaid by addressing Dr. D. J. Ameel, Manhattan, secretary of the Academy. Attention of all members is also directed to the list of other Academy publications appearing on the back cover of this issue.

Sigma Xi, honorary scientific fraternity, has two chapters in Kansas: one at Kansas State College, Manhattan, and the other at the University of Kansas. Election to Sigma Xi is based either on scientific achievement of note or upon promise of scientific achievement as indicated by aptitude for research and academic record. During the past scholastic year, the two state chapters have elected to Sigma Xi the following new members in the scientific fields indicated:

Kansas State College — Tom R. Thomson, *Chemurgical Research,* Los Gatas, Calif.; Travis E. Brooks, *Mycology,* Lawrence, Kans.; Emery J. Coulson, *Biochemistry,* Takoma Park, Md.; Henry W. Loy, Jr., *Biochemistry,* Arlington, Va.; Gilbert G. Noble, *Civil Engineering,* Topeka, Kans.; Ralph W. Sherman, *Entomology,* Montclair, N. J.; Lyman D. Wooster, *Animal Ecology,* Hays, Kans.

University of Kansas—Barbara E. Russell, *Bacteriology,* Lawrence; Robert W. Taft, Jr., *Chemistry,* Lawrence; Elmer S. Riggs (life member) *Paleontology,* Lawrence; C. Phillip Kaiser, *Geology,* Lawrence; LeRoy G. Moore, *Chemistry,* Lawrence; Robert R. Russell, *Chemistry,* Lawrence; Henry W. Setzer, *Zoology,* Lawrence; Manuel Maldonado, *Zoology,* Mexico City, Mexico; Lawrence B. Lynn, *Physics,* Pittsburgh, Pa.; Leland S. Bohl (associate member), *Eng. Physics,* Kansas City, Mo.; Donald C. Cronemeyer (associate member), *Eng. Physics,* Chanute, Kans.; Edward J. Zimmerman (associate member), *Physics,* Downs, Kans.

The *Transactions* extends its congratulations to each of these newly elected members and wishes for each a long and satisfying scientific career.

Dr. Ralph L. Parker, professor of entomology at Kansas State College, Manhattan, is on leave of absence for service with the Bermuda Department of Agriculture to investigate the death of many of the colony's cedar trees. Reports reaching this country state that Dr. Parker has discovered that the trees are not diseased but infested with red spider mites, which are severe pests in Kansas as well as in Bermuda. Dr. Parker has devised a dusting and spraying treatment for the destruction of the pests.

Dr. J. M. Jewett, staff member of the State Geological Sur-

vey, supervised the drilling of test holes along the axis of a proposed dam on the Arkansas River near Hartland in Kearny County in April. Drilling was done by the drill crew of the State Geological Survey of Kansas and the United States Geological Survey. The investigations were done for the State Board of Agriculture under the direction of Mr. George S. Knapp, to whom Dr. Jewett will give a report on the geological conditions at the dam site. The proposed dam, which will be about one mile long, will impound water to be used in irrigation.

Dean L. E. Call of Kansas State College, Manhattan, has been appointed as a member of a special committee to review and approve rules governing participation in an award program sponsored by the James F. Lincoln Arc Welding Foundation of Cleveland, Ohio. Some 131 cash awards totaling $37,500 will be given by the Foundation in various divisions with the object of encouraging the scientific investigation and development of arc welding in farm operations and maintenance.

Professor N. W. Storer, the astronomer of the University of Kansas, has moved to quarters on the roof of the new mineral industries building, Lindley Hall. Here Professor Storer is truly nearer the stars and among the clouds and has the advantage over most of us ordinary mortals in that he seldom needs to come down to earth.

One of the interesting research programs which have been under way since 1937 at Kansas State College, Manhattan, is the intensive investigation of starch. This project, under the supervision of Dr. H. N. Barham of the department of chemistry, was established as part of a more general study of the industrial utilization of sorghum grains and other Kansas crops. The studies on starches have followed two principal courses. One has been concerned with a study of the pasting behavior of natural or slightly modified starches. Such pasting properties determine the suitability of a starch for use in sizing, in making adhesives and in making edible products. The present knowledge of sorghum starches thus obtained show them to be superior to corn starch for food purposes, a superiority which is particularly true of kafir starches.

The other course of investigation has involved the production of deep-seated chemical changes in various starches secured chiefly by chlorination. Chlorination produces reactive intermediates which hold possibilities of yielding useful products of both high and low molecular weight. Two procedures have been found for the formation of such chlorine containing derivatives of starch; one of these procedures may, upon further investigation, yield reactive intermediates of low cost. It seems probable that some of the high molecular weight products may be converted into plastics and some of the low molecular

weight compounds into commercial acids.

Stratigraphy of the Marmaton Group, Pennsylvanian, in Kansas, by John M. Jewett, is the title of the most recent bulletin (No. 58) published in April by the State Geological Survey of Kansas. Copies are available at the office of the State Geological Survey in the Mineral Resources Building, Lawrence, or it may be secured for a mailing charge of 25 cents by addressing the Survey.

The bulletin describes in detail the stratigraphy of the Marmaton group which comprises four limestone and four shale formations that lie above the Cherokee shale and in the upper part of rocks of Desmoinesian age in Kansas. The Marmaton rocks outcrop in a belt that extends from Linn and Bourbon Counties on the Kansas-Missouri boundary to Labette and Montgomery Counties on the Kansas-Oklahoma line. The outcrop belt ranges in width from about 10 to 25 miles. The rock units are described in detail and 179 stratigraphic sections measured in Kansas are given. Several sections measured in neighboring parts of Missouri and Oklahoma are included. The Marmaton group of rocks offers excellent opportunities for studying cyclic deposits and both cyclothems and megacyclothems are described in the report.

The Manhattan High School Science Club held its annual contest of demonstrations and talks on May 2nd. Six members of the club were awarded honors by the judges, Professors Eric Lyons, Roger Smith and Ralph Silker, all of Kansas State College. Mr. Ralph Rogers, sponsor of the club, and all three judges are Academy members and the club itself is one of the most active among our Junior Academy organizations. Grand prize was awarded to Richard Griffing for his demonstration on "Pig Embryology".

Other awards were made as follows:

Demonstrations — Second place, John Greene; Third place, Tennyson Collins.

Talks—First place, Roy Wonder; Second place, Ralph Shellenbaum; Third place, Robert Thayer.

Mr. Morris Teplitz, for several years research associate with the University of Kansas Research Foundation, has been engaged in experiments on the conversion of natural gas to other useful products, a project sponsored by the Kansas Industrial Development Commission. Encouraging results have been obtained in the development of catalysts for producing carbon monoxide and hydrogen from natural gas and steam at temperatures lower than those usually employed. It is planned to use such hydrogen-carbon monoxide mixtures for the synthesis of organic compounds.

We are happy to announce that Dr. Alexander Wetmore, Secretary of the Smithsonian Institution in charge of the U. S. National Museum in Washington, was unanimously elected an honorary member of the Acad-

emy at its annual meeting on April 14. Dr. Wetmore, a former Kansan, has brought great credit to himself and has reflected part of that credit on Kansas through his orthnithological researches and by his newly acquired scientific position of national importance. In fairness to the National Academy of Sciences, we should mention that Dr. Wetmore was also elected a member of this organization a week or so after his election as honorary member of the Kansas Academy. We would like to point out, however, that, although election to the National Academy is much the greater honor, election to honorary membership in the Academy is really attained with greater difficulty than to the National Academy for Dr. Wetmore is the first honorary member to be elected by the Kansas Academy in thirty-seven years. The last previously elected honorary member, our readers may be interested to know, was Dr. T. D. A. Cockerell, the author of the featured review in this issue, who was elected in 1908.

Two new topographic maps, the Andover quadrangle in Sedgwick and Butler Counties and the Moscow Quadrangle in Grant, Haskell, Stevens and Seward Counties have just been published and can be obtained from the State Geological Survey at the University of Kansas or from the U. S. Geological Survey, Washington, D. C., at a cost of 10 cents each.

Major R. C. Moore, state geologist, absent on leave for military service, was a visitor on the K. U. campus on Thursday, April 19. After a day of inspection of the new home of the State Geological Survey in the recently built Mineral Resources Building, Major Moore flew to the Pacific coast on a military mission.

Professor S. L. Loewen, past chairman of the Academy zoology section, will serve as director of the summer session at Tabor College, Hillsboro, during the coming summer.

Mr. Harry Rosenstein has recently accepted a position as research associate in chemistry at the University of Kansas and has begun an investigation on the synthesis of fluorine compounds. Mr. Rosenstein, who secured his master's degree from the University of Nebraska, is an army veteran of three years' experience taking part in the Guadalcanal and northern Solomons campaigns. Prior to his army service, Mr. Rosenstein was employed for four years by the Northern Natural Gas Company with headquarters at Omaha.

The last few years have brought increasing interest in the scientific development of the resources of the states centering around Kansas City. In our last issue we described briefly the industrial research foundation organized at Wichita University. In addition to this foundation, there are a number of other research centers with various objects in this same region. We hope eventually to describe all of these scientific organizations.

Among the first of these organizations to get under way was the Midwest Research Institute of Kansas City, Missouri. Through the interest of a number of business and industrial leaders in Kansas City, preliminary steps for the formation of the Institute were begun in June, 1943, and a permanent organization was formed and an application for charter filed in Kansas City on December 1, 1943. A fund of more than half a million dollars was subscribed by the industrialists and others interested in its formation. The first large-scale research project, begun in July, 1944, was a study of adapting crystalline ammonium nitrate produced by the Military Chemical Works, Inc. of Pittsburg, Kansas, for use as commercial fertilizer.

Mr. Harold Vagtborg, the organizer and director of the Armour Research Foundation, Chicago, was elected president of the Midwest Institute and took active charge on January 1, 1945. Under Mr. Vagtborg's direction the following scientific staff has been employed:

Dr. George E. Ziegler, physicist and senior scientist.

Dr. George W. Ward, geologist and mineralogist.

Dr. Frank H. Trimble, applied physics.

Dr. C. L. Shrewsbury, agricultural chemist.

Dr. Frank E Horan, chemist.

Dr. Elza O. Holmes, physical chemist.

Dr. Milo J. Stutzman, process and research metallurgist.

Mr. Stewart Clare, entomologist and biochemist.

Mr. M. N. Schuler, chemist.

Miss Jane Hathaway, chemist.

Miss Margaret Gill, chemist.

The Institute, which is a nonprofit organization and is to be self-sustaining, has already negotiated contracts to the extent of $400,000 for projects of investigation with the following firms:

Gas Service Company.

Corn Products Refining Company.

Folger Coffee Company.

Military Chemical Works, Inc.

W. J. Small Company, Inc., Neodesha, Kansas, alfalfa dehydration.

The Carnation Company, milk and other food products.

Standard Oil Company of Indiana.

Phillips Petroleum Company.

Gustin-Bacon Manufacturing Company, fiberglass products for armed services.

Vendo, Inc., radar and other communication devices for armed services.

Kansas City Testing Laboratory.

Chicago Bridge and Iron Company.

Manley, Inc., popcorn processors and distributors.

Robert S. Leonard Company, manufacturer of bottle caps.

Sonken-Galamba Corporation, refiners of secondary nonferrous metals.

Other types of projects now under negotiation by the Institute include flour storage, utilization of wheat milling offal, plastics, candy, dental products, cotton seed oil, glass containers, melting and brewing, metallurgy and electronics.

General offices and main laboratories of the Institute are located in the Campbell-Taggart Research Corporation building at 4049 Pennsylvania avenue. The old Westport fire and police station building at Fortieth street terrace and Pennsylvania has been converted into a model machine shop and will house the minerology and engineering divisions. The physics section is located on the second floor of the

Wheeler building at Westport road and Broadway.

Dr. H. C. Tracy, for 25 years a member of the department of anatomy at the University of Kansas, retires from administrative duties as departmental chairman on Sept. 1, 1945. Dr. Tracy will continue his work as professor of anatomy but will be succeeded by Dr. Paul G. Roof of the University of Louisville as head of the department. Dr. Roof, who secured his doctorate from the University of Chicago, has been at Louisville for over ten years. At one time (1925) he was instructor in chemistry at Haskell Institute, Lawrence.

Dr. E. V. McCollum, professor of biochemistry at Johns Hopkins University and honorary member of the Academy, recently underwent a major operation. His Kansas friends will be glad to learn that he is making a satisfactory recovery. We can also report that Dr. McCollum was honored on April 19th by election to the American Philosophical Society.

In recent months two well-known paleontologists have visited Dyche Museum, University of Kansas, and have made investigations of certain paleontological specimens in the Museum. Dr. Paul McGrew, curator of vertebrate paleontology of the Chicago Museum of Natural History, made a number of casts of fossil horse teeth in connection with his study of the fossil horses of North America; and Dr. David Dunkle, curator of vertebrate paleontology of the Cleveland Museum, has been making various studies, especially in connection with the Museum's extensive collection of fossil fishes.

Professor Richard N. Bender, formerly of Boston University, has replaced Forrest D. Kellog as assistant professor of psychology at Baker University, Baldwin, for the second semester of the current year.

In war times most Academy members spend their time the year around on the same familiar grind. Others are able to get work in the summer that comes as welcome relief to the familiar routine which at the same time contributes to the war effort. Among those in the later class is Dr. R. E. Mohler, professor of biology at McPherson College. During the coming summer, Dr. Mohler will act as farm manager for some fourteen wheat ranches in Kansas and northern Texas as he has done during the past several summers.

Dr. Winston Cram, professor of physics at Kansas State College, Emporia, has returned to the College after a year's leave of absence. Dr. Cram has been working the past year for the Sylvania Electric Products Company of Flushing, N. Y., where he was supervisor of electronic research and new tube construction. With the termination of war contracts, he returns to Emporia, where he will teach in the coming summer session.

Dr. Stuart M. Pady, associate editor of these *Transactions* and

professor of biology at Ottawa University, will again be on duty this summer as plant pathologist for the U. S. Emergency Plant Disease Prevention Survey with headquarters at Manhattan.

Dr. Roy Browning, formerly of the University of Kansas Extension Division, has been appointed professor of psychology at Ottawa University, succeeding Lt. Adrian Tielemen, resigned.

Mr. Harold Regier, science teacher at Hillsboro high school, will be in residence at Kansas State College, Manhattan, during the coming summer. With the aid of hard work, intelligence and good luck, Mr. Regier hopes to finish his work for the master's degree by the end of the summer.

You may have wondered about the cause of the many heated and opposing arguments that have occupied the press in recent months concerning the Missouri Valley Authority. It is a subject that should concern all who live in the Missouri River basin. A readible explanation of the various points at issue and of the many diverse interests involved will be found in the May *Harper's Magazine*. The article "Golden River" was written by Joseph Kinsey Howard.

Changes in the scientific staff at Bethany College the past year include the resignations of Kenneth L. Johnson, assistant professor of biology and Dr. Joe L. Hermanson, professor of physics and chemistry. Mr. Johnson is now on the staff of Iowa State College, Ames, and Dr. Hermanson is professor of chemistry at Gustavus Adolphus College at St. Peter, Minnesota.

WHEN A KANSAS SUMMER WAS PARADISE

. . . here is a view of Fort Leavenworth—the acknowledged Eden of the beautiful West. On the north the great Missouri washes the base of the hill upon which the fort seems almost to repose, embowered as it is amongst the huge elm and oak, and walnut trees, that fill its parade, and surround it on every hand. High above them can be seen towering aloft, the tapering flagstaff, supporting a gorgeous drapery, which, as it slowly unfolds in the breeze of the morning, reveals itself to be the magnificent banner of our country—pictured with all its brilliant emblazonry, in strong relief against the pure blue of heaven. Then away to the west, and the south, and the east, can be seen, as far as the eye can reach, hill and dale— woodland and prairie—luxuriously sleeping in the soft haze, that ever more or less pervades, during the summer season, the atmosphere of the West. 'Tis indeed a lovely scene—one which would almost make Apollo, or Pan, enamoured of earth again, could they but catch one glimpse of it. Besides, there is no Midas here to oppress either of them. It is nature—all nature! Man has not yet marred its beauty. And save those elegant buildings that seem clustered together beneath that flag—reflecting back with their pure white the morning's sunlight as it struggles down through the deeep green foliage above—or the little wreaths of blue smoke, which here and there curl gently upwards from the distant groves, marking the spot where the red man has built his rude wigwam—nothing that man has done sullies the picture. In all else it is as it came from the hand of the Creator. This description, if it may be called one, is not overdrawn, but falls far short of the reality. All who have once visited this spot, will say that no pen could ever do justice to its loveliness.—From Lieutenant J. Henry Carleton's logbook written at Fort Leavenworth, Aug. 12, 1844.

It is the scientist who can teach us to solve our problems and evaluate our data—if he will take the trouble to do so. And if we can solve problems rather than make orations about them, if we can evaluate our data instead of exalting or condemning them, we shall act like adult human beings rather than infants.

Unfortunately, we are much too inclined to act like infants; and those who might lead us towards maturity, the scientists, are often too preoccupied to do so. Scientists are too much inclined to do what we laymen do, and emphasize the results of their efforts rather than the method whereby they get the results.

Yet it is in method that scientists can best contribute to human enlightenment. The results of scientific inquiry are beyond imagination, and the use to which they may be put is beyond imagination. But all this is in the realm of things, which most of us are conceited enough to suppose is not to be equated with the realm of humanity. The great contribution that the scientist can make to human development is furnishing means to determine what is relevant to human welfare. There is nothing we lack so dismally as the ability to determine relevance. Scientific method is a means to such determination. Would it not be desirable, then, for this Academy, and other scientists as well, to cease for the moment emphasizing results and emphasize method?

Few of us will become scientists. Facts and specific knacks that we may learn in elementary courses in any science will soon be forgotten. If on the other hand we are imbued with scientific method, we may grow up to act like adults. It is in your hands to develop adult conduct. Would it not be a good time to consider ways and means to do so, when the world is suffering so horribly from pathological infantilism?—Dr. S. A. Nock in his address of welcome before the seventy-seventh annual meeting of the Kansas Academy of Science.

Presidential Address
Kansas Academy of Science
1945

Micro-Organisms and the Struggle for Existence

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INTRODUCTION*

In searching for a topic around which to gather a few thoughts suitable for this occasion, it occurred to me that there is a lack of appreciation on the part of many persons of the role of micro-organisms† in the struggle for existence. It was perhaps with more zeal than wisdom that I selected such a subject, since part of the evidence which provides substantiation can only be inferred.

DR. L. D. BUSHNELL

In discussing the mutual relationships between man and the remainder of the biological world, most writers consider only the visible forms of life, plants and animals. However, the invisible world of the microbe is vast in extent and rich in various forms of life. It is so common for us to measure everything in the light of our knowledge and inner experience that we forget that much lies beyond our horizon, and we are continually startled to discover that our horizon is not the frontier of the universe. The place which microbiology will occupy in the intellectual order of tomorrow will be determined in large measure by the information available to society and the ability

*Contribution No. 228 from the Department of Bacteriology, Kansas Agricultural Experiment Station.

†The terms microbe and micro-organism are used to designate all microscopic forms of life including viruses, bacteria, yeasts, molds, rickettsia, protozoa and algae.

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and talent of the society to absorb it. For that reason it is the purpose of this paper to call attention to some of the influences of this invisible world on the human struggle for existence.

Free Energy

One of the most striking characteristics of living organisms is their perpetual state of change. In order to effect these changes energy must be expended. In this connection Helmholtz[1] distinguished between "free" and "bound" energy and considered only that part of a system which could do work as value.

In discussing this point Bayliss[2] says that a further important fact is, that free energy always decreases if it possibly can, but never, of itself, increases.

As Boltzman[3] pointed out in 1905, the struggle for existence among living beings is not primarily for the fundamental constituents of food, which are nearly everywhere present in earth, in air and water; nor even for energy, as such, which is contained in the form of heat, in abundance in all bodies; but for the possession of free energy, obtained chiefly by means of the green plant, from the transfer of radiant energy from the hot sun to the cold earth.

Vernadsky[4] maintains that the functions of living organisms in the energetics of the biosphere has been seriously neglected. He believes that bio-geochemical energy may be expressed by the velocity with which the biosphere could be colonized by a given species. He states: "For certain bacteria, the limiting velocity of extension of a dividing chain of cells, tending to embrace the whole circumference of the earth, would tend to approach the velocity of sound." This possibility appears absurd at first thought but an organism one micron in diameter, with a not unusual generation time of 30 minutes, and unimpeded development, could surround the diameter of the earth about as rapidly as sound could cover the same path. Although such a statement does attract attention to the energetics involved in microbial development, it is doubtful if we should compare the speed of two things, one of which is moving at a uniform rate, and the other on the basis of geometrical progression.

Preparation of the Environment

Due largely to observations in the field of geology we have a certain historic record of life as it has existed at various periods of the earth's history, and from this record we can learn something of the life-forms at different ages. This record indicates that life has changed from the simple to the complex in form and structure.

Although the record is not complete for the microscopic forms the theory of evolution would lead us to believe that the earliest living forms were very simple one-celled structures.

Micro-organisms have played a greater part in the forming of fertile soil than is usually recognized. Soil is extremely complex, consisting not only of insoluble mineral elements, but in addition, certain amounts of organic matter and a large number of microscopic forms of life. Great solvent action is ascribed to waters due to the CO_2 and other acids produced by microbial action. It has been reported that such decomposition may extend to rocks from 100 to 300 feet beneath the surface.

Waksman[5] points out that by enrichment with specific compounds it has been possible to establish definitely that soil harbors an extensive microbiologic population, hundreds of genera of fungi, actinomycetes and algae, numerous families of protozoa, nematodes, and other worms and insects.

Micro-organisms are also important rock formers. There is ample evidence that they are probably the most active agents now in existence in the formation of organic sediments and sedimentary rocks in most areas of the earth, both on land and in the ocean. Recent studies show the importance of bacteria in the formation of extensive calcium deposits in the neighborhood of the Florida Keys. Geologists consider that many of the purer limestones are due to bacterial action.

Drew[6] has suggested that bacteria are important in the formation of calcium carbonate, which is continually being precipitated at Tortugas. The organism responsible for this was named *Bacillus calcis* (*Pseudomonas*, sp.). This microbe lives near the bottom of the sea where a minimum of 160,000,000 per ml. were found in the muds collected from certain areas.

Nearly all rocks contain iron. During decomposition of such rocks considerable amounts go into solution, mainly as ferrous bicarbonate and iron salts of organic acids. The iron is later precipitated in sedimentary deposits in the form of oxides, hydroxides, silicates and sulfides. These vary from small masses less than a foot in thickness to great beds hundreds of feet thick. Some of these beds are believed to be due either to the direct action of iron-oxidizing micro-organisms, the true iron bacteria, or to the indirect action of micro-organisms in general, other forms of bacteria, the protozoa, algae and fungi. At present these organisms are found in nature wherever there is iron in solution. No doubt they have been present

in similar situations throughout geologic time and have accounted for enormous deposits of iron ore.

Micro-organisms are also important in the formation of sulfur beds. Such deposits are found around springs and bodies of water low in oxygen. The hydrogen sulfide which occurs under these conditions is in part due to the decomposition of organic matter and in part to the reduction of sulfates. The oxidation of the hydrogen sulfide leads to the precipitation of fine particles of free sulfur. Sedimentary sulfur is also present in gypsum, limestone and organic matter. By bacterial action very extensive nitrate deposits have been formed in caves, and at one time nitrate plantations were conducted for the commercial production of saltpetre. This substance was used mostly in the manufacture of gunpowder.

Bacteria exert an influence on the formation of certain types of sedimentary deposits in all parts of the earth. At the present time such deposits are being formed over large areas, especially on the bottom of the ocean. Under such conditions petroleum is also formed, where it frequently collects in pools. Oil pools usually rest on salt water which is believed to originate from sea water in which the sediments were laid down. These pools are probably the result of microbial action. This is indicated by the fact that rocks formed from those sediments show very little evidence of having been subjected to either abnormal heat or pressure. Illing(7) states that in most cases "Temperature could not have been more than 100°C., for the temperature gradients of such rocks are low, and the cover is usually not more than 20,000 feet."

Trask(8) studied the composition of marine deposits and found appreciable quantities of organic matter, particularly in those along the flanks of submarine basins. These organic mixtures contained little of the original fats, proteins or carbohydrates, but were composed rather of complex residual substances which result from bacterial decay. Such organic matter tends to become enriched in carbon and hydrogen by the elimination of oxygen and nitrogen. Trask believed that bacteriological action ceased with the transformation of the organic matter into residues, since he was unable to find any appreciable quantities of petroleum in modern sediments. He also reported(9) that ancient sediments contain almost as much organic matter as those of more recent origin. However, some writers do not consider this as conclusive proof that bacterial changes do not occur, since formation of petroleum is not necessarily contemporaneous with sedimentation, and fossil bacteria and petroleum have been

found in recent deposits of oil-bearing rocks. Zobell and Anderson[10] observed many millions of bacteria per gram of marine sediments. In some cases they were numerous in the deep layers where petroleum is most likely to be formed. It may be true as Kreps[11] has suggested that enzymes, or organic catalysts, accumulate in the bottom of the sea where they activate chemical transformation independent of micro-organisms. This point has not been proved.

Haas and Bushnell[12] have found that certain organisms can utilize many hydrocarbons as sources of energy and yield complex end products (beta-carotene). There is at least some evidence that certain bacteria can synthesize long-chain hydrocarbons from simpler forms. Apparently it is necessary to have some directing force to control their action.

The sediments which ultimately contain petroleum are in the main clays, marls and limestones. From this it would appear that the petroleum must have been formed from the organic matter which was originally enclosed. Such oil-source rocks are widely spread over the surface of the earth, which would indicate a normal phase in marine sedimentation. It is quite possible that bacteria may play a major role, not only in the formation of such rocks, but at the same time saturate them with petroleum compounds. Bushnell and Haas[13] reported that one of the types of bacteria most active in changing petroleum fractions in the laboratory was closely related to the type which Drew found was able to precipitate limestone in the bottom of the ocean. (*Pseudomonas,* sp.).

We may wonder how it is possible to account for such a great variety of petroleum products as have already been described. Eaton[14] had listed more than 800 different compounds by 1938. Lind[15] in explaining their great chemical complexity states: "On examining the general thermodynamic relationship in reactions between saturated hydrocarbons, generally one finds that they involve but little free energy. For this reason, there is no driving force to cause interaction, and under ordinary conditions they are quite inactive toward each other. On the other hand, since there is no driving force in any direction, there are no large opposing forces to be overcome; in other words, the heats of reaction are low. Furthermore, if suitable conditions are found to produce reaction, and since there are no large directing forces, one may expect reaction to take place in any direction and to proceed by successive steps in all directions, hence to a great complexity of product, without having to assume such variety in the original source."

Antiquity of the Microbe

The nature of the first organisms is unknown. We have, however, good evidence that micro-organisms were among the first inhabitants of the earth, because (1) they can adapt themselves to wide extremes of temperature; and (2) they can live on simple food stuffs, utilizing the free nitrogen of the air and the carbon dioxide of the water. The presence of algae and bacteria in the ancient pre-Cambrian rocks was suspected for several years before they were found. From the part they both play in the deposition of calcium carbonate in modern waters and the fact that bacteria are usually present where animal or vegetable matter is broken down by decomposition, it seems that they must have existed almost from the beginning of life on earth.

In his discussion of his mass-time triangle, Dodd[16] places the origin of life on earth at a period many millions of years ago. Arranged according to mass the viruses are placed prior to the bacteria and the bacteria prior to ameba in time of origin.

Importance of Plants and Animals

In a discussion of the importance of plants, Robbins[17] states that they are the "basis of life." "In the last analysis they supply us with all the food we eat, they maintain the oxygen content of the air and they are the primary source of those important accessory foods, the vitamins. Without plants we would starve to death, die of suffocation and expire from a combination of deficiency diseases. In addition plants are the chief means by which the energy of the sun is, and has been in ages past, caught and stored in a usable form."

In a paper presented in the *Transactions of the Kansas Academy* in 1944 Call[18] stated that in 1942 Kansas farms produced 38,135,000 tons of plant material. He also called attention to the fact that this amount can be duplicated year after year.

To the surface crop should be added about one-third that amount of plant materials in the root systems. This means that for each tillable acre of Kansas soil about two and one-half tons of organic matter were produced. If this plant material was approximately 45% carbon, about 8,250 pounds of CO_2 per acre were required for its development. It is also estimated that Kansas soil loses some 500 pounds of organic carbon per acre per year, or an equivalent of some 2,000 additional pounds of CO_2. It is admitted that all the CO_2 utilized to build plant tissue does not originate from microbial action, but it is probably a safe estimate that micro-organisms make available the total amount of CO_2 necessary to produce a crop each year.

In addition to carbon dioxide the soil microbes render available for plant crops some 35 pounds of nitrogen per acre. For 20,000,000 acres this would be 350,000 tons. Practically all this is rendered available by microbial action, either by nitrification or nitrogen-fixation.

A major part of the plant growth, and all the energy developed in 1942 has disappeared by this date. We may wonder what has become of it. The carbon, nitrogen, oxygen, hydrogen and mineral elements are now in condition to be used for the building of a like amount this summer. The rendering of these compounds available for the coming crop was not due solely to the action of plants and animals. We must admit that plants are important to mankind. Yet, if it were not for the part played by micro-organisms in preparing the soil in which plants live, there would be no plants.

The role played by animals is more difficult to evaluate since animals depend directly or indirectly on plants as a source of food. The egocentric attitude of man is well illustrated by Vernadsky(4) in a recent statement in which he says: "During the past century, man, for the first time in the history of the earth, knew and embraced the whole biosphere and colonized its whole surface. Mankind became a single totality of the life of the earth." With his last statement I do not agree, since many micro-organisms can live with comparative ease under conditions which mankind would find intolerable.

Macallum(19) has pointed to the fact that the ionic composition of the bloods of different animals have been maintained without significant modification in spite of millions of years of evolution along widely divergent paths. This fact strongly suggests that the conditions under which animal life is possible are very restricted indeed. There appears to be a systematic cooperation between plants and animals—fixity is the law of the plant, movement the law of the animal. Thus it may be that animals are merely responsible for the distribution of plants.

Microbial Relationships

So far in the discussion, I have attempted to show that many of the factors which promote plant growth are prepared and conditioned by microbial action. The reason for the excessive metabolism of bacterial cells is due to the great surface area in proportion to volume. The surface area of a rod shaped organism, having a volume of about 0.000,000,002 cmm. would be nearly 0.000,01 sq. mm., and the organisms in a gallon of sour milk which weigh only about 0.4 mg. would possess a surface of 350 sq. ft. According to Rahn(20)

a lactic acid organism can produce its weight of lactic acid (18×10^{-10} gm.) in one hour under the most favorable conditions of fermentation.

At first thought, 50,000,000 bacteria per gram of soil appears large, however, compared to the space which they occupy, the plant life is more crowded than the microbial life, since the bacteria occupy only one-tenth per cent of the space available. If we consider total weight of microbes in the soil we have quite impressive figures. Considering one acre-foot of soil as 3,500,000 pounds Russell(21) has estimated that it would contain approximately 2,000 pounds of bacteria, protozoa, fungi and algae. Thus the weight of micro-organisms in the soil correspond fairly well to the weight of live stock which the soil will support.

According to Waksman(5) considerable evidence has accumulated which serves to emphasize the fact that not only do microbes assist one another in creating favorable conditions for growth but that they exert a variety of functions whereby they influence the activities of others unfavorably. In 1879, DeBary called these unfavorable influences "antibiosis."

The antibiotic compounds which attract the most attention are those which suppress the development of pathogenic bacteria. In the past few years at least 30 such compounds have been isolated from various groups of micro-organisms, mostly fungi. This branch of science can now be properly called "The Moldy Science."

Waksman(5) has summarized the action of these substances in part as follows: 1. Some act primarily upon bacteria, and others on fungi; 2. some influence cell division, others affect cellular respiration, still others interfere with the utilization of metabolites; 3. some are capable of acting upon a great number of organisms, and others upon only a few; 4. they vary in their toxic effect upon the animal body and in the reactions upon the tissues; 5. some are water-soluble, and others only alcohol-soluble. From such behavior it may be seen that they are complex in nature and very diverse in action. At least four such compounds are now being used for the control of infections in man and animals.

Influence of Micro-organism on the Origin of Species

One point in which I have been interested for some time is the possible influence of micro-organisms on the origin of species among the more highly developed biological forms.

L. H. Bailey(22) once wrote that heredity is an acquired character, and that, normally or originally, unlike produces unlike. He

stated that the proof of evolution is based on two facts: 1. That there must be a struggle for existence from the mere mathematics of propagation; and 2. that there must have been mighty changes in the physical character of the earth. These facts argue that organisms must have undergone radical change from time to time or perished.

More than three-fourths of a century has passed since Darwin wrote *The Origin of Species* and still the relation between life and its environment presents itself as an unexplained phenomenon. Natural Selection, or Survival of the Fittest, is the preservation in successive generations of those types which happen to be least at variance with requirements for survival. This expresses the fact of survival without designating the cause of origin. There seems to be ample evidence that the environment has played a dominant role in the survival of species and perhaps in their modification. Someone has suggested that the environment may graft new branches on the tree of life or apply a pruning knife to it.

The influence of micro-organisms on the origin of species of plants and animals cannot be proved. During the past ages many new species developed. Some of these may have come about because of the direct or indirect action of micro-organisms. Those who seek a morphological basis for heredity regard genes as the real factors in the differentiation of individuals during development. Genes are believed to be present in pairs, one from each parent, in all the chromosomes of every cell from the zygote on. There is also ample evidence that many different specific genes are located in each chromosome, since the number of characters expressed in a cell is in excess of the number of chromosomes present. This concentration of genes would make it possible for a small amount of dislocation to initiate marked changes in the cell without involving much of its structure.

Needham[23] believes that certain biochemical agents called organizers, inductors, evocators, and the like may explain structure and behavior. What a part of a cell becomes may be due to the inducing substance itself, or to the ability on the part or the cell to react. Hargitt[24] states that if certain types of proteins are capable of self-reproduction we may have the basis for the duplication and perpetuation of molecular patterns. "It may not be acceptable much longer to claim that reproduction is a unique biological property as contrasted with a non-biological substance believed to be devoid of this property."

It seems to me that except for certain fortuitous maladjustments of the genes, which we must admit are very rare, the chief agents responsible for such rearrangements would be: 1. viruses, which are the only known active agencies small enough to perform such an act without destroying the cell itself; and 2. other microbial forms which are a great force in evolution since they are the only agencies which exert much influence on the medium in which other biological forms must survive.

Stanley[25] states that "all viruses contain nucleoproteins and all viruses have the ability to reproduce when placed within living cells." It may be that certain viruses are capable of producing toxins, growth factors or nucleoproteins which have power to perpetuate new molecular patterns and account for the evolution of new types. It is also to be kept in mind that viruses were probably among the earliest organisms on this earth.

THE ORIGIN OF MICROBIAL PARASITES

An activity of micro-organisms which is recognized by everyone is that they cause infectious diseases. There is some debate about how these organisms acquired this characteristic since many of these types were believed to be present on earth before the advent of man and animals. If this theory is correct such parasitism must have developed due merely to adaptation.

Among highly developed forms variation may come about in a number of ways, perhaps by gene mutation, combination of genes, or loss of a gene. It must be remembered that bacteria do not develop a discrete nucleus, they may not have chromosomes, and apparently reach no sexual stage, and consequently no cross fertilization is possible. Some may consider that bacteria do not possess genes since it is estimated that there would be room for only 20 to 50 linerally arranged genes in the microbial nucleus, even though they are no larger than protein molecules. Since the microbe is so small in size and simple in structure it cannot possess enough genes to account for all its characteristics; whatever variation occurs, therefore, may be ascribed to changes in its enzyme systems rather than to gene modifications.

The enzyme systems of animals and plants are relatively constant. This is not true in the case of bacteria. These organisms are able to adjust their fermenting power to varying conditions. Microbial cells contain two enzyme systems; one known as "constitutive", which is present within the cell regardless of its past history; the second, known as "adaptive" will increase or decrease according to

its substrate. Alteration in the adaptive enzyme can occur within a very short time—two hours for *Azotobacter,* according to Harris[26]. However, even the constitutive type may be altered by conditions of growth. Such a change would be slow to develop and would exact a deep-seated change in the cell. If such a change occurred it might be regarded as the equivalent of the loss of genes as seen in higher forms.

In the evolution of a parasite from a non-parasitic form there is probably a loss of essential enzymes when necessary food substances are obtained from the tissues of the host. If such changes continued long enough the character of the organism would be changed permanently. It is now known that the organisms which multiply in a living body are controlled by laws wholly different from those affecting dead matter. The forces necessary to maintain a parasitic existence may be greater than those needed by free-living species, although not so diversified. In external nature the rate of multiplication depends chiefly on the accumulation of waste products; in the living host on the resistance of the host cells. These influences would lead to variation among these cell types.

The resistance on the part of the host has forced parasites to act in a number of ways. Some disease producing organisms are injurious because they produce toxic products, as in diphtheria and tetanus; others because they build excessive amounts of foreign proteins, as in anthrax and fowl cholera; others because of products of fermentation, acids and gases, in gas gangrene and blackleg; others because they sensitize the cells of the host to foreign protein and render them allergic as in tuberculosis and brucellosis; others because of cell destruction, as in malaria and coccidiosis. From these few illustrations it is evident that the processes of parasitism are very complex.

No doubt new types of parasites will develop in the future as in the past. Such modification has been observed with the tubercle and brucella groups of bacteria and with the pox and influenza viruses. The prolonged residence in one type of host stamps a parasite with certain characteristics. The bovine tubercle bacillus attacks a number of hosts, but the reservoir of supply is always cattle. Swine are very susceptible to this organism, and if it could be passed through a series of swine we should in time have a porcine type which would differ from the bovine type, as the bovine type now differs from the human type.

One type of variation has become known as microbic dissociation in which colonies of bacteria change from smooth to rough in appearance. The action of bacteriophage is particularly marked in inducing such changes. This change in the gross appearance of the colony reflects a rather profound change in the characters of the bacteria. In many cases the morphology of the cell is altered, and more important, the virulence is lost.

Industrial Microbiology

Attention should be directed to the influence of micro-organisms on American industry. By reading the annual reports of the U. S. Department of Commerce(27) it is possible to gain a fairly accurate idea of the total industrial activities in this country, but no idea whatever of those which are based on microbial activity. For that reason I am calling attention to this point.

The list of manufacturing processes which deal directly with micro-organisms is quite impressive. They may be arranged into several large groups, since time will not allow for a detailed list.

1. Food processing—baking, making of butter, cheese, sauerkraut, pickles.
2. Food conservation—canning, refrigeration, drying, quick freezing.
3. The production of fermentation products—alcohols, organic acids, glycerol, acetone and others.
4. Production of antisera, vaccines and other biologics.
5. Preparation of drugs, disinfectants and antibiotics.
6. Manufacturing of fermented and distilled liquors.
7. Microbial processes concerned with leather, textiles, and fibers.

In addition to the above there are certain industries somewhat indirectly influenced by microbial activity. These would include concerns involved in—

1. Manufacturing of tin plate and glass containers.
2. Manufactured dairy products.
3. Meat packing.
4. Hospital and laboratory equipment.
5. Equipment for water purification and sewage disposal.
6. Storage of grain and feed.
7. Agriculture.

Also we should consider certain professional services, all influenced in some degree by action of pathogenic organisms: medical, dental, veterinary, hospitals and clinics, funeral directors and embalmers.

In many of these industries micro-organisms are used as reagents to produce desired end products such as foods and chemicals. During 1939 some 192,200 tons of cabbage were used in the manufacture of sauerkraut; pickles and olives were processed in much the same manner. Similar action is involved in the curing of tobacco. Certain products of fermentation are now being used for making synthetic rubber. Bread, butter, cheese and preserved foods are produced in impressive amounts in American homes. We should not overlook the many thousand tons of silage which is essentially a fermented product designed for stock feeding.

There are also a number of fermentation products such as butanol, acetone and organic acids which are used in a wide variety of industrial processes. Pasteur was the first to show that butyl-alcohol was a direct product of fermentation. Many investigators studied the process but the need for synthetic rubber resulted in the first commercial process about 1909. Synthetic rubber at that time was made through the polymerization of isoprene and butadiene. These compounds were prepared from two fermentation products, isoamyl-alcohol and n-butyl alcohol.

At the time of the last war large quantities of glycerol were prepared by fermentation. Beginning about that time there were developed extensive industrial plants for the preparation of fermentation products used in the manufacture of explosives and as solvents for paints, lacquers, plastics and many other commercial products.

Many organic acids, used for industrial purposes, are being produced by fermentation. These include acetic, lactic, propionic, tartaric, gluconic and citric. Of these substances, citric acid has been produced commercially in the United States by mold fermentation for 25 years. Gluconic acid is now widely used in the preparation of pharmaceutical products.

Investment in commercial plants used for the manufacture of antiseptic, disinfectants and antibiotic compounds is no small item. The manufacture of penicillin alone is now backed by a $20,000,000 investment. There are acids, alcohols, alkalies, halogens, salts of heavy metals, phenols, cresols and related compounds, aniline dyes and miscellaneous alkyls, formaldehyde, and peroxides offered for sale to the general public and advertised widely in the press and over the radio solely for the control of microbial growth. Scarcely a week passes in which some new product is not described. It is probably true that we spend as much time and money in trading on the activity of micro-organisms as we do on those of plants or animals.

Micro-organisms and Public Health

In the field of medicine and public health micro-organisms play a significant role. During peace time probably one million persons in this country are engaged in these services annually. In 1941, an average year as far as the civilian population is concerned, the U. S. Public Health Service reported 2,464,081 cases of infectious diseases[27] for the country as a whole, while Kansas reported 48,816 such cases.[28] It is well recognized that some years these numbers are much higher. It should also be recognized that probably not more than half the cases of infection are recorded. The above discussion ignores the heavy annual losses sustained as a result of infections of plants and animals.

Conclusions

The reason why micro-organisms act as they do is difficult to explain. Some writers believe that there is a specific design in nature and that there is a close adaptation of the means to the end. Biochemical investigation has led to the discovery of many facts and to the identification of many compounds which would appear to support this view. In spite of this view the doctrine of teleology explains nothing and a belief in it may delay the search for reasons and causes. Many things can be explained on a mechanistic basis. To date, however, no one has explained the vital impetus at the very origin of things, just before mechanism begins to act. Perhaps, as biologists, we should not be concerned with the reasons why matter and energy have been organized in time and space as we now find them. It is known that this arrangement will support life, but the more we investigate it, the more inscrutable it is found to be. At least from a practical standpoint we can prove that micro-organisms have in ages past played a major role in the struggle of man for his existence on this earth.

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Further Studies on the Occurrence and Distribution of Physiologic Races of Tilletia foetida in Kansas*

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INTRODUCTION

Bunt or stinking smut, *Tilletia foetida* (Wallr.) Liro, is one of the major diseases of wheat in Kansas. The average annual loss in yield for the state during the last 30 years has been 2,500,000 bushels (4). There are additional losses due to reduced market value of contaminated wheat used for milling purposes, and to explosions and fires in threshing machines, elevators and mills. Since bunt greatly affects the quality of flour, special means of cleaning or scouring smutted grain are necessary to remove the spores. This process involves extra expense to the milling industry which, in turn, pays less to the farmer who sells smutty wheat. Dockage may vary from a few cents to a considerable amount per bushel.

Bunt is most commonly controlled by treating the seed prior to planting with fungicides such as New Improved Ceresan and copper carbonate. Breeding wheat varieties that are bunt resistant is another important way to reduce the losses. There are, however, many difficulties in such a program. Besides having resistance to bunt, a variety of winter wheat for Kansas must have good yielding capacity, be winter hardy, be free from shattering, have stiff straw, be early enough to escape hot weather, and have good milling and baking qualities. It is also desirable that the variety should be resistant to other major diseases as the rusts and loose smut and to major wheat insects as the Hessian fly.

In breeding bunt-resistant varieties of wheat, the investigations at the Kansas Agricultural Experiment Station are carried on cooperatively by the Departments of Botany, Agronomy, Entomology, and Milling Industry with the cooperation of the Division of Cereal Crops and Diseases, Bureau of Plant Industry, Soils, and Agricultural Engineering, U.S.D.A.

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One of the essential steps in breeding a bunt-resistant wheat for Kansas is to learn what physiologic races of *Tilletia foetida* occur in the wheat area. The investigation recorded in this article was conducted to determine the number, prevalence, and distribution of physiologic races of *T. foetida* in Kansas.

Physiologic Races of *Tilletia Foetida*

Bunt is caused by two species of fungi, *Tilletia foetida* (Wallr.) Liro (*T. laevis* Kühn) and *T. caries* (DC.) Tul. (*T. tritici* (Bjerk.) Wint.). *T. foetida* is characterized by having smooth chlamydospores, while those of *T. caries* are reticulate. Kellerman and Swingle (2) in 1889 and Norton (5) in 1896 reported *T. foetida* as common in the state, while *T. caries* was collected in only Rooks and Greeley Counties. Specimens of *T. caries* collected in Rooks County by Bartholomew in 1894 and placed in the Kansas State herbarium have been examined by the writers and are correct for this species. However, all collections of bunt made in Kansas during the last 20 years have been identified as *T. foetida.*

Within these species of Tilletia there are physiologic races which are fairly similar morphologically but which differ in pathogenicity on wheat varieties. A physiologic race of either of these species consists of a group of biotypes which have the inherent ability to infect one or more differential varieties of wheat. The number of physiologic races that may be determined depends on the number and kind of differential varieties of wheat used and the fineness of distinction that is made on the reaction of these varieties to the smut.

During the last 20 years several investigators have determined physiologic races of the bunt fungi, each using a different set of differential varieties. The first investigational work on this problem in Kansas was done in 1934 by Melchers (3) who made a study of the races of *T. foetida* and their distribution in Kansas. In 1937 Rodenhiser and Holton (7) used 10 differential wheat varieties to determine the physiologic races of these fungi. In 1942 they (1) added two additional varieties. These varieties have been adopted as the "standard set" to be used in the identification of physiologic races of *T. foetida* and *T. caries* in the United States.

Ten physiologic races of *T. foetida* have been identified in the United States (1). With the use of the letter R for resistant (0-10 percent infection), I for intermediate (11-40 percent infection), and S for susceptible (41-100 percent infection) the reactions of

the differential varieties to the different races of *T. foetida* are shown in Table I.

TABLE I

Reaction of physiologic races of *Tilletia foetida* to the differential varieties*

Variety	L-1	L-2	L-3	L-4	L-5	L-6	L-7	L-8	L-9	L-10
Hybrid 128	S†	S	S	S	S	S	S	S	S	S
Ridit	R	R	R	R	R	R	R	R	S	I
Oro	R	R	R	R	R	R	R	S	R	R
Hohenheimer	R	R	R	R	R	R	R	R	R	R
Hussar	R	R	R	R	R	I	S	R	I	R
Albit	R	R	R	S	S	S	S	R	S	R
Martin	R	R	R	S	S	S	S	R	R	R
White Odessa	R	R	R	S	S	S	S	R	S	R
Ulka	S	S	S	S	S	S	S	S	I‡	S‡
Marquis	I	S	S	I	S	S	I	S	I‡	S‡
Canus	R	R	S	R	S	S	S	S	S‡	S‡
Mindum	I	I	I	I	I	I	I	I	-	-

*From Holton and Rodenhiser (1).
†R=Resistant (0-10 percent infection); I=Intermediate (11-40 percent infection); S=Susceptible (41-100 percent infection).
‡Unpublished data from Holton and Rodenhiser.

Races L-9* and L-10 are characterized by the S and I reactions, respectively, of Ridit. L-8 is characterized by the S reaction of Oro. L-6 and L-7 are characterized by the R reaction of Ridit and Oro and by the I and S reactions, respectively, of Hussar. L-4 and L-5 are characterized by the R reaction of Ridit, Oro and Hussar and by the S reaction of White Odessa. Canus is resistant to L-4 but susceptible to L-5. L-1, L-2, and L-3 are characterized by the R reaction of Ridit, Oro, Hussar, and White Odessa. Canus is resistant to L-1 and L-2 but susceptible to L-3. Marquis is intermediate in reaction to L-1 and susceptible to L-2.

These 10 races of *T. foetida* may be identified in the following key by the reactions of six of the above differential varieties.

KEY FOR THE IDENTIFICATION OF PHYSIOLOGIC RACES OF *Tilletia foetida* IN THE UNITED STATES

Ridit resistant
  Oro resistant
    Hussar resistant
      White Odessa resistant
        Canus resistant
          Marquis intermediate 1
          Marquis susceptible 2
        Canus susceptible 3
      White Odessa susceptible
        Canus resistant 4
        Canus susceptible 5
    Hussar intermediate 6
    Hussar susceptible 7
  Oro susceptible 8
Ridit intermediate 10
Ridit susceptible 9

Resistant (0-10%); Intermediate (11-40%); Susceptible (41-100%).

*L-9 has reference to *T. foetida* race number 9.

Determination of the Physiologic Races of *T. foetida* in Kansas

During the last 15 years a large number of collections of *T. foetida* were made in different counties in Kansas. Recently most collections have been made from farmers' samples of wheat grown in the Kansas Wheat Improvement Association master nursery at Manhattan. A study of these collections in a special bunt nursery has given a record of what physiologic races of *T. foetida* occur in the wheat area of Kansas.

In 1940 and 1941 seed of five differential wheat varieties, Ridit, Oro, Hussar, White Odessa and Canus, and of the highly susceptible variety Chiefkan was inoculated with 100 collections from 57 counties and planted in two replicated 8-foot rows in the field. The winter differential varieties were planted in the bunt nursery the latter part of October and the early part of November when the average soil temperatures were 55° F. or lower. The spring variety Canus was planted by C. S. Holton at Pullman, Washington.

The results of this physiologic race study are shown in Table II. Eighty-two of these collections were classified as L-3. To these collections Chiefkan averaged 80 percent bunt, Ridit 2 percent, Oro 2 percent, Hussar 0.2 percent, White Odessa 0.4 percent, and Canus 85 percent.

One collection was classified as L-4. Chiefkan and White Odessa were susceptible to this collection, while Ridit, Oro, Hussar and Canus were resistant.

Seven collections were classified as L-5. Chiefkan, White

Table II

Percentage of Bunt Produced on Differential Varieties by Four Physiologic Races of *Tilletia foetida* from 100 Kansas Collections of Bunt. Manhattan, Kans., 1941-1942.

Variety	L-3, 82 col. Percent Avg.	L-3, 82 col. Percent Range*	L-4, 1 col. Percent Avg.	L-5, 7 col. Percent Avg.	L-5, 7 col. Percent Range*	L-7, 10 col. Percent Avg.	L-7, 10 col. Percent Range*	Percent uninoculated
Chiefkan C.I. 11754	80	60-90	90	89	85-90	86	80-90	1
Ridit C.I. 6703	2	0-4	4	1	0-4	1	0-3	0
Oro C.I. 8220	2	0-6	4	1	0-4	3	0-4	0
Hussar C.I. 4843	0.2	0-4	1	1	0-5	44†	39-55†	0
White Odessa C.I. 4655	0.4	0-8	51	55	44-70	66	43-97	0
Canus‡ C.I. 11637	85	60-95	5	65	32-76	84	67-93	3

*Variation in reaction of variety of wheat to different collections.
†Percent infection at Pullman, Wash., 57, range 51-78.
‡Data from C. S. Holton, Pathologist, U.S.D.A., Pullman, Washington.

Odessa, and Canus were susceptible, while Ridit, Oro and Hussar were resistant.

Ten collections were classified as L-7. Chiefkan, Hussar, White Odessa, and Canus were susceptible, while Ridit and Oro were resistant.

Distribution of Physiologic Races of *T. foetida* in Kansas

It was important to learn in what parts of Kansas the several races of bunt occurred. The 82 collections of L-3 were made in 55 different counties. These counties are distributed over the state (fig. 1). The collection of L-4 was found in 1928 in eastern Kansas in Johnson County. The seven collections of L-5 were made in Atchison, Brown, Clay, Franklin, Johnson, Montgomery, and Reno Counties, all of which are in the eastern half of the state. The 10 collections of L-7 were made in Lane, Leavenworth, Lincoln, Mitchell, Norton, Pratt, and Sedgwick Counties. These counties are distributed over the state. It is of interest to note that three of the four collections of Mitchell County and one of the three collections of Lincoln County were L-7. The predominance of L-7 in these counties suggest the possible distribution of this race by some seed grower in that part of the state.

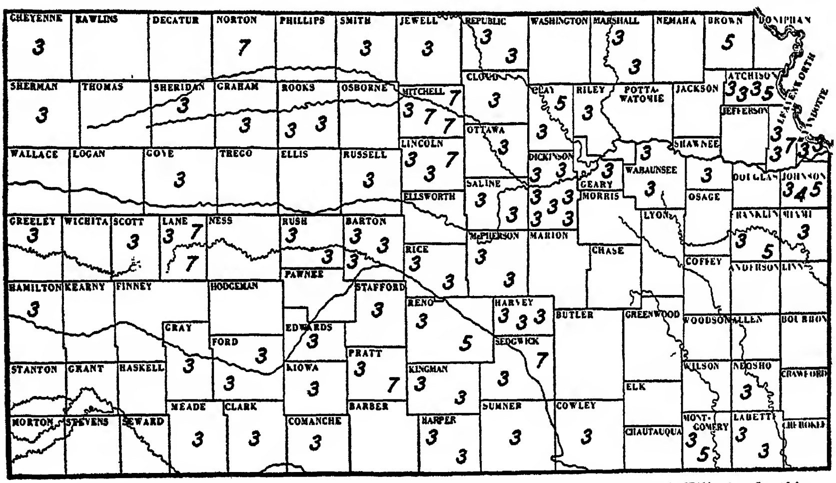

FIG. 1.—Number, prevalence and distribution of physiologic races of Tilletia foetida in Kansas.

Physiologic Races and Breeding Disease Resistant Varieties

The determination of the physiologic races of *T. foetida* which occur in Kansas is very important in connection with the breeding of bunt-resistant varieties of wheat as was emphasized a number of

years ago (3), because a variety of wheat may be resistant to one race of *T. foetida* and susceptible to others. Therefore, a new variety should be resistant to all races of bunt in the state, and better still, to all races of *Tilletia foetida* and *T. caries* which occur in the United States.

Comanche, a bearded hard red winter wheat, was released by the Kansas Agricultural Experiment Station (6) in 1943. This variety is a selection from the cross Oro x Tenmarq made specifically for the purpose of obtaining a bunt-resistant wheat. Oro is resistant to all of the races of *T. foetida* except L-8. Tenmarq is susceptible to bunt but has good agronomic qualities. Comanche has the bunt resistance of Oro and the agronomic qualities of Tenmarq. It is recommended for the south central, central, and southwestern parts of Kansas where bunt frequently causes heavy loss.

Discussion

In 1934 Melchers (3) tested the reaction of 64 Kansas collections of *T. foetida* and described 7 physiologic races on the basis of the reaction of six differential wheat varieties. From the data obtained the following key was prepared for the identification of physiologic races of *T. foetida* in Kansas.

	Race No.
Banner Berkeley resistant	
Hussar highly resistant	
Oro highly resistant	
Ridit highly resistant	
Turkey Sel. highly resistant	1
Turkey Sel. moderately susceptible	4
Ridit moderately susceptible	5
Oro moderately susceptible	6
Hussar moderately susceptible	3
Banner Berkeley susceptible	
Martin resistant	7
Martin susceptible	2

On the basis of recent studies (7) and present experimental investigations, Melchers' races 1, 4, 5, and 6 may be reclassified as Rodenhiser and Holton's L-3. This reclassification may be explained partly by the use of different differential varieties, and partly because a less fine distinction is made at present in the reaction of Ridit and Oro to certain races. In some years under Kansas environmental conditions Ridit and Oro are slightly susceptible to certain collections of *T. foetida*. Rodenhiser and Holton (8) explained simi-

lar differences by stating that the expression of genetic factors for protoplasmic resistance in the host is modified differently in different varieties by environment.

Melchers' race 3 (Hussar race) is similar to Rodenhiser and Holton's L-7. This race has gradually increased in Kansas, as shown by the fact that certain of the early collections (1931) contained only small percentages (4 percent or less) of L-7. By propagation on Hussar year after year in the bunt nursery, mixtures of other races were strained out and the proportion of L-7 increased. Similar results were obtained by Melchers (3) who observed an increase in infection on Hussar from 7 percent in 1930 to 47 percent in 1931 when smut from Hussar was used as inoculum. In addition, a higher percentage of the collections made during the last 10 years has been classified as L-7 than from those formerly collected (3).

Melchers placed two collections in race 2. In this present study one of these collections has been identified as L-4 and the other as L-5 by their reaction on the variety Canus. In this case the number of physiologic races was increased by the use of this differential spring wheat variety. Melchers' race 7 is similar to Rodenhiser and Holton's L-5 (7).

SUMMARY

Differential wheat varieties were inoculated with 100 collections of *Tilletia foetida* from 57 counties to determine the number, prevalence and distribution of physiologic races in Kansas.

Of these, 82 were classified as L-3, one as L-4, seven as L-5, and 10 as L-7.

The use of different differential wheat varieties in some cases reduced the number of physiologic races of *T. foetida* which occur in the state, while in one case it increased the number.

The determination of physiologic races of *T. foetida,* their prevalence, and their distribution in Kansas is of paramount importance in connection with the present and future breeding of varieties of wheat that will be resistant to bunt.

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Dental Caries in Wild Bears

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Of American, wild-taken bears, 384 specimens (195 subgenus *Euarctos,* black bears and 165 subgenus *Ursus,* grizzly and big brown bears) in the collections of the University of California Museum of Vertebrate Zoology and the University of Kansas Museum of Natural History were examined for dental caries. Six *Euarctos* and three *Ursus,* or nine bears in all (2 per cent), had dental caries. Of 3,401 other specimens of wild-taken American carnivores and 2,256 insectivores examined* in the first-mentioned collection, no instance at all of dental caries could be found.

Why should bears, alone, among these animals have dental caries? In pondering this question a person recalls first that bears, among all the Carnivora, have molars with low rounded crowns which most resemble the corresponding tooth-surfaces in man. The suggestion, then, is that in these two kinds of animals, bears and man, so extensively affected by dental caries, the occlusal faces of the teeth because of their characteristic topography may in some mechanical way, now unknown, lend themselves, better than in other animals, to penetration of the enamel and decay of the dentine. On second thought, I recall that the abovementioned similarity in tooth-form is probably an adaptation to an omnivorous diet and that other mammals of unrelated kinds that are omnivorous have molar crowns of corresponding form—pigs (Suidae) and peccaries (Tayassuidae), for example, have similar teeth but I have no knowledge of the frequency of caries in their wild (free-living) populations.

By thus remarking on a general similarity of food habits (omnivorous as opposed to, for example, carnivorous, insectivorous or herbivorous), one is led to consider diet itself and the question of whether there be a parallel between, on the one hand those dentally carious persons among men, and on the other hand the bears, similarly afflicted among the Carnivora. In the voluminous literature on dental caries,† students of the subject commonly maintain that a

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*See Hall, E. Raymond. Supernumerary and missing teeth in wild mammals of the orders Insectivora and Carnivora, with some notes on disease. Journal of Dental Research, vol. 19, pp. 103-143, April, 1940.

†McCollum, E. V. 1931. Relationship between diet and dental caries. Journ. Dental Research, vol. 11 (p. 554), pp. 553-571.

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PLATE I

Ursus americanus subsp.?, Telegraph Creek, British Columbia, ♂ adult, No. 31017, superior dentition and left mandibular dentition. x1.

diet rich in sweets, especially in the earlier years of life, predisposes individuals of man to dental caries. Now bears, among the Carnivora, are notoriously fond of honey. The bears eat it at every opportunity. The black bears climb trees to get it. Bears eat blue berries and other berries exclusively at certain seasons, I am told. These berries are rich in sugar. Also, it is reported that acorns, beechnuts and chestnuts make up an important part of the food of black bears in some seasons and places. I confess that I do not see that these nuts contribute much free sugar to the diet. But, then, bears eat many things, as befits an omnivorous mammal, and the fact remains that their diet as a whole is exceptionally rich in sweets. This fact is significant, I suspect. My failure to find any dental caries in the wild-taken polar bears, which like the uncivilized Eskimos, a class that had good teeth, get but little in the way of sweets and rely upon seals as one important item in their carnivorous diet, may be the exception, among the several kinds of bears, which proves the rule. In all only 16 polar bears have been examined for dental caries—a number too small to allow of our being certain that they are exceptional among bears in being free from dental caries.

The specimens which are affected with dental caries may be commented upon as follows:

One black bear that had dental caries is No. 31017 (unless otherwise indicated, catalogue numbers refer to the collection at the University of California). No. 31017, shown in Plate 1, is an adult male but not an aged individual. Most of its teeth are unworn and a few are only slightly worn. The last molar on the right side above and the one on the left side below are carious and in each tooth, decay has reached the pulp cavity. The first left upper molar is worn to an unusual degree and may be slightly carious.

The black bear, No. 53396, shown in figures 1, 2 and 3 of Plate 2, is a male, perhaps slightly older than the preceding specimen. In No. 53396, each molar tooth, both above and below, is worn to an unusual degree, in itself suggestive of a deficiency in the teeth and in addition, decay has begun in three upper molars and in the first lower molar on the right side.

The female black bear, No. 4708, shown in figures 4 and 5 of Plate 2, needs comment because decay is not nearly as extensive as the photographs suggest. Most of the blackened areas on the occlusal surfaces of its teeth are the result of a black deposit which can easily be scraped away from either the sound enamel or from the worn areas of dentine. Even so, there definitely is decay in the second lower molar, and the first molars above are worn to a degree which suggests some deficiency in them.

An adult male with unworn teeth from Kenai Peninsula, Alaska, is Univ. Kansas Mus. Nat. Hist., No. 2965, *Ursus americanus perniger*. This specimen, not figured, has a cavity, approximately 2 mm. in diameter, resulting from decay in each first upper molar and in each first lower molar. Incipient cavities are represented by decay in areas of pin-point size on each of the second lower molars.

The adult, but not especially aged, male black bear, No. 53398, shown in figure 1 of Plate 3, has the molars so greatly worn that in some teeth the pulp cavity is revealed. At some of these places decay has set in and in the

PLATE II

Figs. 1, 2 and 3. Ursus americanus altifrontalis, Kleena Kleene River, B. C., ♂ adult, No. 53396, occlusal views of maxillary and mandibular molariform teeth. x1.

Figs. 4 and 5. Ursus americanus perniger, Kodiak Island, Alaska, ♀ ?, No. 4708, occlusal views of maxillary molariform teeth and right mandibular teeth. x1.

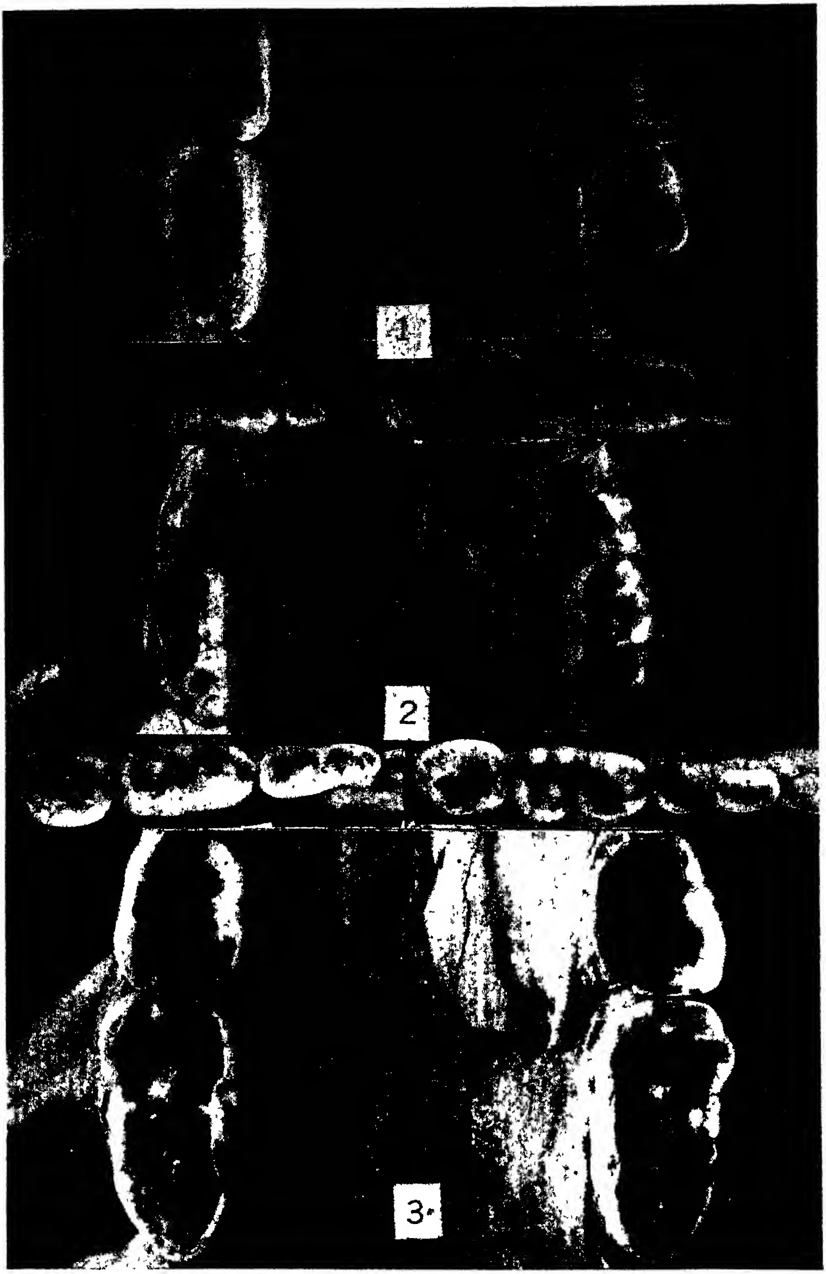

PLATE III

Fig. 1. Ursus americanus altifrontalis, Kleena Kleene River, B. C., ♂ adult, No. 53398, occlusal views of maxillary and mandibular molariform teeth. x1.

Fig. 2. Ursus americanus americanus, 31 miles south of Telegraph Creek, B. C., ♀, No. 31018, occlusal views of maxillary and mandibular molariform teeth. x1.

Fig. 3. Ursus rungiusi rungiusi, Goose Creek, Barkerville district, B. C., sex ?, No. 43323, occlusal view of maxillary molars. x1.

first molar, on the left side above, decay has separated the inner fourth of the tooth from the remainder all the way to the tip of the root. A dento-alveolar abcess resulted, with considerable destruction of bony tissue on the lingual side of the roots, suppuration occurred round the detached lingual fourth of the molar, and fibrous plant material had worked its way into the lesion.

The barely adult female black bear, No. 31018, shown in figure 2 of Plate 3, evidently had some deficiency of the teeth which permitted excessive wear at a relatively early age. In the first upper molar on the right side wear has exposed the pulp cavity and decay appears to have begun there.

The aged grizzly, probably a male, whose upper dentition is shown in figure 3 of Plate 3 has the molars much worn as befits the age of the animal. In the first upper molar of the left side the pulp cavity is exposed and at first glance the blackened area suggests that decay has set in. Closer inspection reveals that the margins of the pulp cavity are firm and hard and that the tooth is free of decay. Other aged specimens were found resembling this one which is selected for special mention to show the care which one must exercise to distinguish the effects of excessive attrition from those of decay.

The adult grizzly, probably a male, shown in figures 1 and 2 of Plate 4, shows considerable wear on both the upper and lower molars and in addition the last upper molar on each side has carious spots and the dentine in each tooth has been lost to a degree that would not occur with normal wear. A dento-alveolar abcess occurred round the anterior root of the last upper molar on the left side and a more extensive abcess on the right side involved both upper molars. As shown in figure 1 of Plate 4 suppuration with destruction of bony tissue occurred between the molars and also directly above the first molar.

The barely adult male grizzly, No. 46637, whose right upper and lower molariform teeth are shown in figures 3 and 4 of Plate 4, has most of the teeth only moderately worn but has two carious teeth: the first molar on the right side above (fig. 3) and below (fig. 4).

The rather old grizzly, possibly a female, No. 46620, whose right upper and left lower molar teeth are shown in figures 5 and 6 of Plate 4, had actual decay only in the first upper molar on the right side (see fig. 5). The dark areas in the second molar on that side are perfectly hard dentine, although darkly stained. Similarly, in the second lower molar (fig. 6) where wear has exposed the pulp cavity, I can detect no decay; the margins of the pulp cavity are firm.

In review: Bears (subgenera *Ursus* and *Euarctos*) are more frequently afflicted with dental caries than are other wild carnivores, probably because these bears normally eat much food rich in sugar. Supporting this probability is the circumstance that other wild carnivores, for example, raccoons, ring-tailed cats, and gray foxes in all of which dental caries is rare or absent, eat the same general classes of foods when of subadult age as do bears, sweets excepted. The nine individuals of bears which show dental decay are too few to give a basis for sound conclusions. Nevertheless, the idea that dental caries occurs in bears because they eat much food rich in sugar I advance seriously, although only as a suggestion and not as a conclusion. It is clear that dental caries in bears occurs in both sexes and in subadult and adult animals, as well as in aged individuals; indeed the data available indicate that caries occurs less frequently in aged animals than in younger animals.

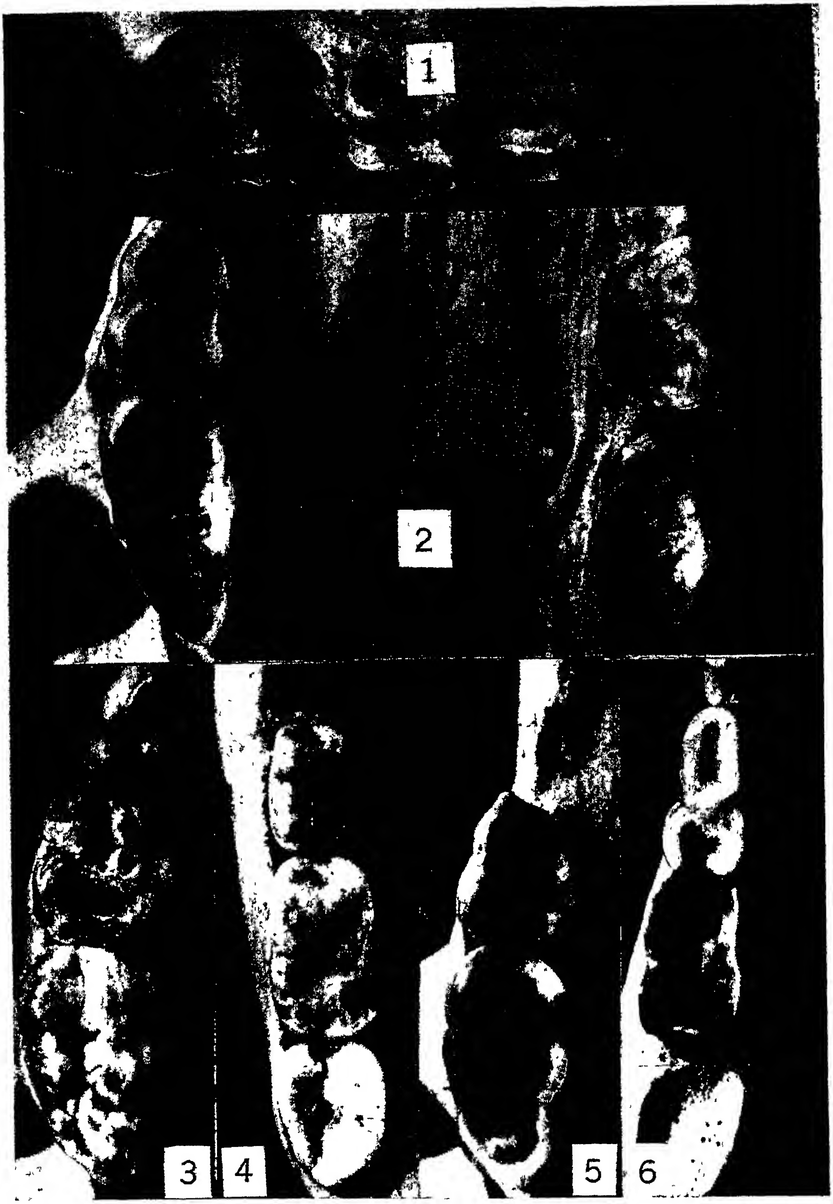

PLATE IV

Fig. 1. Ursus (phaeonyx ?), Kandik River, 40 miles from junction with Yukon River, Alaska, sex ?, No. 78254, *buccal* view of right maxilla. x1.

Fig. 2. Same specimen shown in fig. 1. Occlusal view of maxillary molars. x1.

Fig. 3. Ursus (subgenus Ursus) sp. ?, West fork of St. Marys River, Kimberley, B. C., ♂ adult, No. 46637, occlusal view of left maxillary molariform teeth. x1.

Fig. 4. Same specimen shown in fig. 3. Occlusal view of right mandibular molars. x1.

Fig. 5. Ursus (subgenus Ursus) sp. ?, St. Marys Lake, north fork of St. Marys River, Kimberley, B. C., sex ?, No. 46620, occlusal view of right maxillary molars. x1.

Fig. 6. Same specimen shown in fig. 5. Occlusal view of left mandibular molariform

Amphiachyris Dracunculoides as a Poisonous Plant*

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In eastern Kansas, during the recent drouth decade, *Amphiachyris dracunculoides* (DC.) Nutt., increased in quantity to an amazing extent. Previous to these drouths this plant was known thruout the eastern third of Kansas in open woods, on rocky hillsides, along roadsides, and in the prairie. Under these conditions it is one of the many plants which made but little impression on people. As it became more abundant, it was called "broomweed," although that name more properly belonged to western plants.

With the killing of prairie grasses during the drouths, together with the absence of crops on many of the fields, this annual composite spread into fields, pastures and prairie lands at an amazing rate, so much so in the summers of 1936 and 1937 as to cause a great deal of concern. In several eastern Kansas counties, for example, Chase, Morris, Lyon and Greenwood, whole fields and pastures were literally covered with it.

William Vanderbilt (in a personal communication) reported that in pastures in Greenwood County, Kansas, the broomweeds had grown so high (1-4 feet) and so thick that the cattlemen had difficulty in finding the smaller calves. There he found many pastures with about 10 plants to each square foot, each plant with about 1,500 capitulums (composite heads), each with about 4 seeds, in other words, sufficient to seed many square feet of ground. The roots extended about 6 inches into the ground and branched out in every direction, especially just under the surface, most thoroughly dominating an area of about a square foot. Flowering began in the middle of July and lasted until frost.

Amphiachyris is a plant with a definite odor, not objectionable, but distasteful, so that cattle ordinarily did not eat it. With the extraordinary increase in abundance, however, it was soon learned that cattle would occasionally eat it and whenever they did, gastro-intestinal upsets followed.

That this plant could be poisonous to human beings became apparent when a group of boys, who were transported daily through

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*Contribution No. 465 from the Department of Botany and Plant Pathology, Kansas State College of Agriculture and Applied Science.

fields overgrown with Amphiachyris, developed dermatitis. Those boys who sat with their feet hanging from the end of the truck were continually brushing against Amphiachyris. The dermatitis which followed was at first unexplained, but it was noticed that boys up in the truck did not have it. A little experimentation in rotating boys showed definitely that Amphiachyris was responsible for the skin irritation. None of the cases was particularly severe, but they were sufficiently annoying so that cover had to be provided as a protective measure and bandaging of cases practiced.

Observation of various animals disclosed that mature cattle kept very strictly in paths or roadways through Amphiachyris and avoided both getting into it and eating down thru it, where there was any grass at the ground. No definite skin lesions were found. With calves, however, which were the only young animals available for observation, mild skin lesions were noticed and they appeared to be sufficiently irritating to prevent normal development of the calves. Calves would not keep strictly to roads or paths but would wander into Amphiachyris, and although they quickly learned not to eat it, they did not so easily learn to keep out of it.

The animals which graze in these broomweed infested pastures often develop an eye infection which is quite similar to pinkeye. It does not ordinarily cause the loss of the eye but it might well mean the loss of sight if the most severe cases were not treated. In addition the cattle often develop a constant irritation in their lungs which causes them to cough. The cough, however, does not seem to be serious. The pollen seems to be responsible for most of the injury done by the plant.

Human contacts with broomweed on an extensive scale in mowing or dragging fields and pastures to rid them of the weeds demonstrate further that Amphiachyris poisons human beings as well.

Perhaps the commonest effect is a skin irritation when bare skin comes in contact with the plant too persistently. When exposed for considerable lengths of time to the pollen, eyes became bloodshot and remained irritated for several days and a slight cough developed. Mr. Vanderbilt reported also a weak, wornout feeling, accompanied by a dull headache.

These observations would indicate that *Amphiachyris dracunculoides* has a place on the poisonous plant list of the United States as a plant which is capable of causing gastro-enteritis at least in cattle, but which is sufficiently distasteful not to develop many cases; further, it is capable of causing a disturbance of the eyes, similar

to pinkeye, coughs, and skin irritation (dermatitis) under field conditions, at least in human beings and in calves. Force feeding experiments would doubtless bring out other effects, but in the field the plant is not eaten.

It was expected that following the breaking of the drouth Amphiachyris would dwindle to its former innocuous quantity. This has now (1945) taken place; promptly in fields again cultivated and more slowly in the prairie pastures, where more time was necessary for the perennial grasses to take over the bare spots left by dying grasses and occupied by Amphiachyris at the height of the drouth.

Application of the Electronic Theory to Some Simple Organic Reactions

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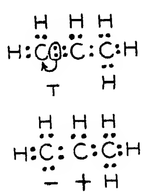
Application of the electronic theory to organic reactions has not as yet come into general or even widespread use in the teaching of chemistry. This fact is probably attributable very largely to the tendency of sponsors of the theory to direct their efforts toward the explanation of complex reactions, often beyond the level of the first year course in organic chemistry, and to neglect the application of the theory to the more simple reactions. This paper, therefore, is an attempt to suggest how the electronic theory may serve as the basis for the study of the characteristic reactions of two common functional groups in organic chemistry.

According to the electronic theory, organic molecules are activated by the development, either permanently or incipiently, of positive and negative centers within the molecule, and a vast majority of organic reactions are initiated by the attack of the positive or negative center of one molecule at the oppositely charged center of the second molecule.[1] Organic reactions initiated in this fashion are termed electron sharing reactions.

The Olefin Function

In the case of simple olefins, for example, this activation results from the tautomeric shift of one of the two pairs of electrons constituting the double bond so as to increase the electron density at one of the two carbon atoms joined by the double bond and to decrease the electron density at the other.

Inasmuch as hydrogen is more highly electronegative than simple alkyl radicals, this tautomeric electron shift in unsymmetrical olefinic hydrocarbons occurs in such a direction as to increase the electron density at the doubly-bonded carbon atom bearing the greater number of hydrogen atoms. In propene, for example, the tautomeric effect may be represented as follows:



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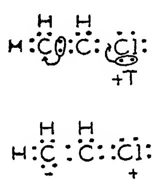
In the general case, the more highly hydrogenated of the doubly-bonded carbon atoms becomes the anionic (nucleophilic or basic) center, and the carbon atom bearing the fewer hydrogen atoms, the cationic (electrophilic or acid) center of the molecule. Normal addition of unsymmetrical reagents to the double bond in olefinic hydrocarbons therefore yields the product in which the anionic atom (or group) of the adding molecule is attached to the more-highly substituted of the two carbon atoms (Markownikoff's rule). Thus, in normal additions to propene, hydrogen chloride, hydrogen bromide, hydrogen iodide, sulfuric acid and water give mainly the isopropyl derivative.

Markownikoff's rule is likewise valid when applied to cases such as that of vinyl chloride in which a halogen atom is attached directly to a doubly-bonded carbon atom. In structures of the vinyl chloride type the negative inductive effect of the chlorine atom is outweighed, insofar as its effect in directing the course of addition reactions is concerned, by the positive tautomeric effect of the chlorine which tends to increase the covalence between that atom and the carbon. Evidence of this type of resonance is offered both by the shortening of the carbon-to-chlorine interatomic distance as compared with that in the saturated alkyl chlorides and by the remarkable lack of reactivity of the vinyl chlorine atom.(2)

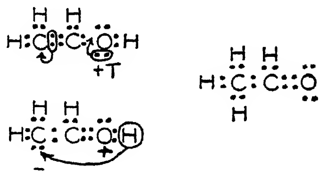
As a result of the positive tautomeric effect of the chlorine atom, one of the two electron pairs constituting the double bond is displaced to increase the electron density of the carbon atom which does not bear the halogen atom, leaving that carbon atom as a reactive anionic center:



In the normal addition of an unsymmetrical reagent, therefore, the cationic center of the adding molecule is attached to the halogen-free carbon, and the anionic center, to the halogen-bearing carbon atom.

Exactly the same type of positive tautomeric effect as that displayed by the chlorine atom in vinyl chloride would be exhibited by the oxygen atom in vinyl alcohol. The well-known fact that the hydrolysis of vinyl halides yields, not vinyl alcohol, but rather its rearrangement product acetaldehyde, is readily explained on the

basis of this tautomeric shift. Resonance about the oxygen atom in the vinyl alcohol molecule would decrease the electron density of the oxygen atom (as a donor atom, the oxygen in the second resonance structure bears a formal positive charge) and increase the electron density on the α-carbon atom (as an acceptor atom, it bears a formal negative charge):

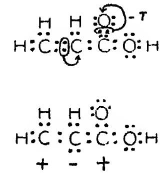


Due to the decreased electron density about the oxygen atom to which it is attached, the hydrogen atom would be rendered rather highly acidic,[3] manifesting a strong tendency for transfer to a negative center bearing an unshared electron pair (basic center). There would be a strongly basic center within the vinyl alcohol molecule itself, namely, the α-carbon atom. Consequently, the shift of the hydrogen atom from the oxygen to the α-carbon atom to form acetaldehyde is nothing more than an intramolecular protolysis in which an acid hydrogen is transferred as a proton to a highly basic center.

The practical advantage of intelligent application of basic theory over blind resort to empirical rule is illustrated by a study of numerous cases involving unsymmetrical addition to double bonds in which Markownikoff's rule leads to erroneous predictions. In the normal addition of unsymmetrical reagents to acrylic acid, for example, the anionic center of the adding molecule adds, not to the α-carbon atom as required by Markownikoff's rule, but rather to the β-carbon atom.

This fact is readily explained in terms of the electronic theory. Inasmuch as the major electron displacement in the molecule is the negative tautomeric effect at the oxygen atom, there is a general shift of the electrons in the chain toward the positively charged (cationic) carboxyl-carbon atom. As a result, one of the two electron pairs constituting the olefinic double bond is shifted toward the α-carbon atom, thereby creating a high electron density or anionic center at

the α-carbon atom and a low electron density or cationic center at the β-carbon atom, as illustrated in the diagram:



It is apparent, then, that the cationic center of the adding molecule should attack the α-carbon atom of acrylic acid.

A comparison of addition reactions of the olefins with those of carbonyl compounds leads to another question: Why do reagents such as hydrogen chloride, hydrogen bromide, elementary chlorine, ozone, etc. add preferentially to the olefinic double bond and not to the carbonyl double bond? The electronic approach to that question is the peculiar contribution of the great English theorist, Lapworth.[4]

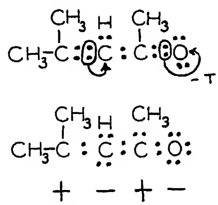
Activated organic molecules possess both cationic and anionic centers, but in general, as Lapworth has so convincingly argued, one of the two centers is definitely more reactive than the other, and the molecule as a whole may be catalogued as predominantly cationic or anionic. The point of initial attack in a cationic molecule is thought to be the cationic center, whereas in an anionic molecule it is the anionic center. After the initial attack, secondary reactions may ocur at the other centers. Because of their tendency to react only with predominantly cationic molecules (Lewis acids) such as halogens, ozone, and strong acids, and because of their failure to add typically anionic (basic) molecules such as ammonia, simple olefins are classified as anionic (basic) substances.*

It is not surprising, therefore, that ease of addition to the olefinic double bond parallels electron affinity (cationic character or acidity) in the case of the halogens and halogen acids. For the halogens, the rate of reaction is $Cl_2 > Br_2 > I_2$, whereas for the halogen acids, it is $HI > HBr > HCl$, with the strongest acid adding most readily.

Despite the fact that the olefinic double bond is catalogued as predominantly anionic in character, this behavior is not an invariable rule. The introduction into the molecule of a sufficiently active electron-withdrawing group may so diminish the tendency of the

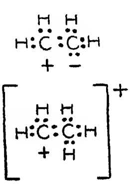
*This conclusion rests upon much additional supporting evidence which is well reviewed by Remick, *Electronic Interpretations of Organic Chemistry*, John Wiley and Sons, Inc., 1943, pages 118-119.

anionic carbon atom to share its electrons and so enhance the electron acceptor qualities of the cationic carbon atom, that the olefinic bond may actually exhibit predominantly cationic character. Such is the case in mesityl oxide, for example, where the active electron-withdrawing carbonyl group so strengthens the cationic nature of the double bond at the expense of its anionic character, that ammonia is readily added at the double bond. The electron displacements involved are represented as follows:



Lapworth's conclusion that most organic molecules are either typically anionic or cationic in character and tend to react only with molecules of the opposite nature appears at first sight to exclude reactions between identical molecules. In the strictest sense, that deduction is correct. A study of the mechanisms of polymerization reactions involving identical molecules reveals that the actual reactions do not occur between identical molecules, although, judging only from the end products of the reaction, one might infer that they did.

In order that identical molecules be made to combine, the normal character of one-half of all the reacting molecules must be reversed, a change which is usually brought about by the catalyst-induced gain or loss of an ion by the molecule itself. Consider, for example, the acid catalyzed polymerization of ethene. If sulfuric acid is the catalyst, the first step in the reaction is postulated as the transfer of a proton from the sulfuric acid to the basic (anionic) olefin molecule forming the ethene carbonium ion and the bisulfate ion:



In the second step, the highly reactive ethene carbonium ion attacks the anionic carbon atom of an activated ethene molecule to form the 1-butene carbonium ion. Transfer of a proton from the

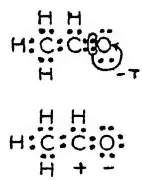
2-carbon atom of the latter ion to the bisulfate ion yields the ethene dimer, 1-butene, and the catalyst sulfuric acid, which emerges from the reaction unchanged.

Experimentally, considerable cyclobutane is formed as a by-product in the acid-catalyzed polymerization of ethene. One may easily explain its formation by postulating that, in the final step, the loss of the proton from the 1-butene carbonium ion occurs in part at the 4-carbon, instead of the 2-carbon, atom.

The Carbonyl Function

Although the carbonyl group, like the olefinic double bond, represents a point of unsaturation in the organic molecule, and, although the outstanding chemical characteristic of each of the two groups is its tendency to undergo addition reactions, nevertheless, the differences in the specific reactions of the two functions are striking. Not one of the typical* reagents which adds to the simple olefinic double bond adds to the carbonyl double bond.

In a simple carbonyl molecule, the major electron displacement is the negative tautomeric effect at the carbonyl oxygen atom. In the active resonance structure, the carbonyl oxygen bears its full complement of eight electrons and a formal negative charge, whereas the carbonyl carbon is left with only six electrons and a positive charge, as illustrated below for the acetaldehyde molecule:



It may be deduced from common experience that the cationic carbon atom should have a much greater tendency to form a covalence than should the anionic oxygen atom. Many stable ions are known involving negatively charged oxygen, whereas an ion involving positively charged carbon would be stable only under extraordinary conditions. In other words, it seems logical that the carbonyl group is predominantly cationic in character, that it normally adds only molecules which are predominantly anionic, and that the initial attack in the addition involves the anionic center of the adding molecule and the cationic carbonyl carbon.

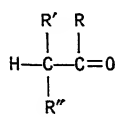
*The behavior of hydrogen in its addition to either the olefinic or carbonyl double bond is atypical, as it is thought to proceed by an electron pairing, rather than an electron sharing, reaction.

In keeping with these postulates, it is well known that carbonyl compounds add only such anionic reagents as ammonia and its derivatives, hydrogen cyanide, and sodium bisulfite. The addition compounds first formed may, especially in the case of ammonia derivatives, subsequently lose water to form unsaturated products. Inasmuch as hydrogen is more highly electronegative than alkyl groups, the carbonyl carbon atoms in aldehydes are more highly cationic than those in ketones, and, consequently, many weakly anionic molecules which add to aldehydes fail to add to ketones, particularly to those ketones which contain weakly electronegative or tertiary alkyl groups.

The problem of teaching beginning students the addition reactions of carbonyl compounds is rendered unusually simple by the fact that all the common adding molecules may be represented by the general formula H-Y, with Y the anionic center and H the cationic center. The addition product formed in the general case, therefore, will always show the Y-group attached to the carbonyl carbon atom and the H-atom to the oxygen.

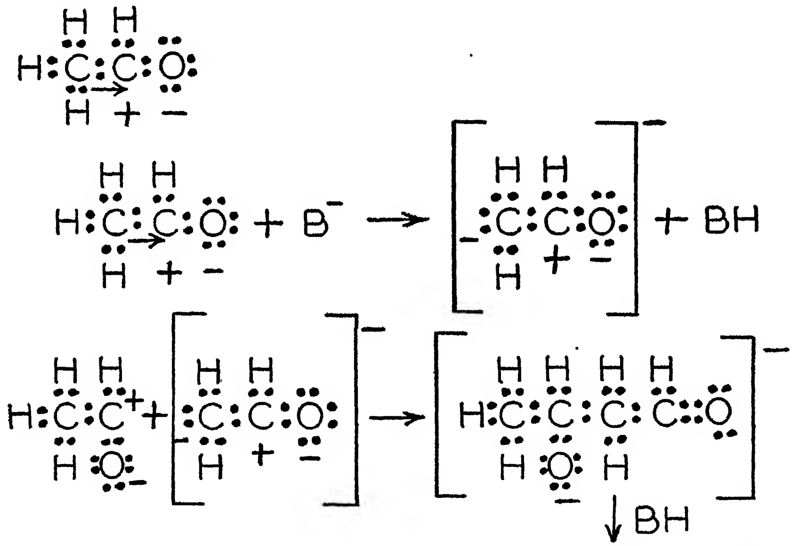
As a matter of fact, the over-all effect of the Grignard synthesis of alcohols from aldehydes and ketones is simply the addition of H-R to the aldehyde or ketone. A saturated hydrocarbon cannot, of course, be added directly to the carbonyl group, but the total result may be achieved in two steps; first, the addition of the Grignard reagent to the carbonyl group with the R-group of the Grignard reagent adding to the carbonyl carbon and the cation X-Mg-group at the oxygen atom, followed by the hydrolysis of the resulting complex to replace the X-Mg-group by a hydrogen atom.

Likewise, the aldol condensation may be represented as the addition to the carbonyl group of the molecule



where R, R′, and R″, respectively, may represent a hydrogen atom or an alkyl group. Once more, in the final product, the hydrogen atom of the adding molecule appears on the oxygen atom of the carbonyl group and the residue of the adding molecule is attached to the carbonyl carbon.

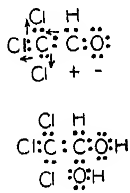
Here again, it is necessary that a catalyst intervene to change the fundamental character of one-half of the reacting molecules if self-condensation is to take place. In the ordinary base-catalyzed condensation, this is accomplished by the basic catalytic ion (B^-) which accepts a proton from the α-carbon atom,* to form a very reactive anion, the carbanion of the original aldehyde or ketone, and the acid BH. The condensation is then consummated by the attack of the carbanion at the cationic carbonyl carbon atom of an activated molecule of the aldehyde or ketone, followed by the transfer of the proton from BH to the anionic oxygen atom of the resulting anion to form the final aldol type compound. In that process the catalytic ion, B^-, is of course regenerated. For the simple case of acetaldehyde these steps are represented as follows:



Organic chemists have long puzzled over the ease with which chloral adds a molecule of water to form a stable hydrate, in violation of the empirical rule that the presence of two hydroxyl groups on the same carbon atom represents an unstable condition which is relieved only by the splitting out of water. From the electronic standpoint, this reaction may be readily explained by the fact that

*Any hydrogen atom attached to the α-carbon atom of a carbonyl compound manifests a slight degree of acidity. This may be explained on the electronic basis both by the fact that the positive charge on the carbonyl carbon is relayed inductively down the carbon-chain thereby lending an α-hydrogen atom "positive" or acidic character, or by the fact that the ion resulting from the loss of a proton from the α-carbon atom is stabilized with respect to its ionogen due to the fact that it can exhibit a higher degree of resonance. See ref. (3) for a complete discussion of these points.

the presence of the three highly electronegative chlorine atoms in the chloral molecule so enhances the cationic nature of the carbonyl carbon atom that even water, which is at best a weakly anionic molecule, may add to the highly reactive carbonyl carbon:



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(4) Lapworth, Nature, 115, 625 (1925).

A Rare Cameloid From the Late Pleistocene Sands of Southwestern Kansas

E. S. RIGGS
Museum of Natural History, University of Kansas

In studying fossil camels of the University of Kansas Museum of Natural History, a rare specimen of cameloid was recognized. This specimen (catalogue number 4799) consists of a right maxillary with well preserved first and second molar teeth moderately worn at the crown, a much reduced fourth premolar and the broken alveolus of a third molar. The specimen was collected by Dr. Claude W. Hibbard and museum party in 1937 from an exposure along Shorts Creek, Meade County, Kansas, sec. 31, T.33 S, R.28 W. The formation, as described to me by Hibbard, is a stream deposit, containing numerous fossil shells. The position of the beds in the Pleistocene section is unknown. This specimen was mentioned by Smith (1940, p. 105) of the State Geological Survey as "a small Pleistocene camel". The mollusks mentioned by Smith were taken just west and across the section line in sec. 36.

Eschatius Cope

To this genus have been referred two species, *E. conidens* Cope and *E. longirostris* Cope (1884).

Eschatius conidens Cope

Proceedings of the American Philosophical Society, XXII, 18-20.

Type.—An incomplete maxillary with full dentition, preserved in the National Museum of Mexico.

Horizon and *locality.*—Pleistocene formation, Valley of Mexico. The specimen here described is referred to *E. conidens.*

Referred Material.—Two other specimens have been referred to the genus *Eschatius.* A fragment of right maxillary with $M^{1,2}$ in position was reported by Troxell (1915, p. 623 fig. 8) from the well-known fossil locality at Rock Creek, Texas. Troxell's figure is the only one of this species previously published. The specimen under description agrees closely with Cope's description of *E. conidens.* The second specimen described by Cope under the name of *E. longirostris* from Silver Lake, Oregon, has been considered as closely related to *E. conidens.*

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Distinctive characters: The extreme reduction of the premolar dentition is the most characteristic feature of *E. conidens.* P^3, present in most other known camels and llamas, is absent entirely from the specimens so far described. P^4 is so small as to be no longer functional. This tooth has a flattened crown with its long diameter set obliquely to the long axis of the molar series.

FIG. 1.—Eschatius conidens Cope, lateral view of right maxillary P^4—M^2.
FIG. 2.—Ventral view of same. x 5/6. Photograph by Bruce F. Latta.

Description.—The following features are observed in specimen No. 4799 from Kansas: M^1 and M^2 are short-crowned and somewhat smaller than those of *Camelus.* M^1 is narrower at the anterior

margin of the first lobe, abutting only the much reduced P^4. The median cleft in both lobes is large and extends downward to the base of the crown. In this specimen the cleft of the first lobe is open posteriorly and the convex surface of the second lobe is thrust into it. The same is shown in Troxell's drawing. This is merely an indication that the teeth are those of a young animal. The antero-external style is reduced, M^2 is somewhat longer in the axial direction than M^1 and its anterior lobe is worn to a more pointed crown. The anterior and the mesial walls of the alveolus of M^3 indicate that the tooth was considerably wider as well as longer than M^2. Troxell's figure shows these teeth in almost identical form, with a small alveolus for the rudimentary premolar.

MEASUREMENTS

	K.U.M.N.H. 4799 mm.	Cope's* type mm.
P^4, greatest length	8.7	.... ..
P^4, greatest breadth	4.5	.... ..
M^1, greatest length	37.1	41.0
M^1, greatest breadth	20.4	.... ..
M^2, greatest length	43.0	44.0
M^2, greatest breadth	23.4	24.0
P^4—M^2, greatest length at base	85.4	.... ..
M^1—M^2, greatest length at base	79.0	.... ..

*After Cope (1884, p. 19).

The infraorbital foramen is not larger actually than that of *Lama guanicoa* (Muller); its position is over the middle of M^1. The postpalatine foramen is actually smaller than that in the llama but the position (opposite the anterior margin of M^1) is the same. The maxillopalatine suture crosses the median suture opposite the middle of M^2 and has the direction and curvature the same as observed in *Lama*.

As indicated by Cope (1884): "this is the greatest reduction of the premolar series known to Ruminantia". No other selenodont articodactyl with equally reduced premolar dentition is known to the writer. The reduction is even greater than in the llama-like *Rakomylus* Frick (1937, p. 657), which, however, has a correspondingly greater expansion of the molar teeth in the longitudinal direction. Nevertheless, the third molar of *Eschatius,* as indicated by the alveolus, was an unusually strong tooth. When the entire skull of *Eschatius* is known, it probably will be found to have still other unusual cranial characters.

The finding of remains of *Eschatius* at places so far apart as Mexico City, Rock Springs in Texas, Silver Lake in Oregon, and Meade County, Kansas, indicates a wide geographic range in late Pleistocene time for this highly specialized cameloid.

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Botanical Notes: 1944

FRANK U. G. AGRELIUS
Kansas State Teachers College, Emporia.

"The Unusual Is Usual in Kansas", and the past year emphasizes the truth of this statement in more ways than one. The total precipitation was the greatest on record with but one exception—that of 1915. In Lyon County we had 51.70 inches—an amount exceeded only by three other counties in Kansas. Probably the highest flood for this county, at least of which there is any known record, occurred on the Cottonwood River. Although there were heavy rains, there were periods when crops were threatened by short droughts.

Among other differences was the scarcity of certain plants found in abundance in some years. A notable case was that of the broomweed or "Fairy Elm" (*Amphiachyris dracunculoides*). This plant had dropped from millions to negligible numbers in some areas—a fact pleasing to owners of pasture land. The Carolina windflower (*Anemone caroliniana*) that has colored the landscape at times, was present only in easily-counted specimens. The most striking scarcity of a certain plant was that of *Viola pedatifida,* often fairly common on the dry prairies. A striking opposite case was the abundance and exceptional beauty of the "Star Grass" (*Sisyrinchium campestre*). It flourished like "the green bay-tree".

An unusual phenomenon was the freezing of the leaves on some plants; a phenomenon that does not usually occur in autumn. The leaves turned brown but did not fall. This happened to Van Houten's Spiraea and other shrubs and was a result of the extended favorable growing season culminating suddenly on November twenty-first when the curtain was rung down and there was no encore.

It was early noted that some plants were extending their growing season considerably; more especially their blooming period. We are listing some of these plants with the date last observed and noted on the following page.

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Caladium esculentum (Foliage)	November 21
Polygonum aviculare	November 21
Aquilegia canadensis	August 7
Capsella bursa-pastoris	November 21
Philadelphus coronarius var. virginalis	November 21
Spiraea Van Houghtii	November 17
Spiraea thunbergii	November 1
Fragaria (Everbearing)	November 21
Rosa sp.	November 1
Trifolium repens	November 21
Phaseolus vulgaris	November 21
Tropaeolum majus	November 21
Ricinus communis	November 21
Althaea rosea	November 21
Hibiscus esculentus	November 17
Ipomoea sp. (Heavenly Blue)	November 5
Ipomoea purpurea	November 17
Ipomoea (Wild blue)	November 17
Lamium amplexicaule (Cleistogamous flowers)	November 21
Mentha piperita (?)	November 21
Lycopersicum esculentum (Including ripe fruit)	November 5
Lonicera tatarica	November 19
Galinsoga parviflora	November 21
Taraxacum officinale	November 21

A New Host Record for the Cestode *Bothridium pithonis* de Blainville 1828.

S. L. LOEWEN
Tabor College, Hillsboro

Some time ago the writer received a vial containing cestodes collected on February 9, 1935, by Grace Wiley from the feces of a captive king cobra, *Naja hannah*. The snake was thought to have come from the Malay Peninsula, Asia.

Upon examination the cestode material was found to consist of two scoleces and several sections of proglottids in all stages of development. This material apparently represents the parts of two complete strobilae, as these pieces could be matched pretty well. In measuring them, the lengths of the two strobilae added up to 635 mm. and 669 mm., respectively.

These cestodes fit the descriptions for *Bothridium pithonis* de Blainville 1828 as given by various authors. The unique characteristic of these tapeworms is the two tubular bothria of the scolex, one on the dorsal and one on the ventral side of the worm. The slight differences in some of the measurements of the worms herein reported and those given by other authors are not specifically significant.

Worms of this genus have previously been reported from boas and pythons: *Constrictor constrictor* and *Eunectes murinus* in South America, *Python sebae* in Africa, *P. reticulatus, P. molurus,* and *Morelia argus* in Asia and Australia. Southwell (1928) reports the tiger, *Felis tigris,* in India as a host of *B. pithonis,* with the parenthetic statement: "(It appears probable that the tiger had been feeding on a python.)". Meggitt (1931) reports finding two specimens of *Bothridium* sp. encysted in the mesentery of the spectacled cobra of Burma, *Naja naja,* suggesting the "possibility of the cobra falling a prey to the python".

The present report appears to be the first where adult cestodes of the genus *Bothridium* have been reported from a cobra. Whether the king cobra is a normal definitive host to *B. pithonis* awaits further evidence.

Transactions Kansas Academy of Science, Vol. 48, No. 1, 1945.

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MEGGITT, F. J. On cestodes collected in Burma. Part II. Parasitol. 23:250-263. 1931.

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The Seventy-Seventh Annual Meeting

The seventy-seventh annual meeting of the Kansas Academy of Science was held at Kansas State College, Manhattan, Kansas, on April 14, with Dr. L. D. Bushnell, Kansas State College, presiding. The affiliated society, The Kansas Entomological Society, met with the Academy; and the local chapter of the American Association of University Professors also held a meeting in cooperation with the Academy.

In deference to the O.D.T. restrictions on the holding of general meetings, the meeting at Manhattan was local in character. The executive committee met at this time for the transaction of Academy business. The meeting was small and was limited to the morning and afternoon but this was the best means possible under the circumstances to maintain the Academy as an active organization. The general enthusiasm of those attending and the character and number of papers offered, served to justify the decision to hold the meeting.

The morning was devoted largely to council and business meetings. The invitational address entitled "Recent Advances in Plant Science" was given by Dr. Walter F. Loehwing, head of the department of botany, University of Iowa, at 10:00 a.m. before a combined college and Academy assembly. This part of the program was broadcast over Kansas State College's radio station KSAC for the benefit of absent members and friends of the Academy.

A noonday luncheon was substituted for the usual annual evening banquet. At this time Dr. Leland D. Bushnell as retiring president gave an address entitled "Micro-organisms and the Struggle for Existence."

During the afternoon, meetings were held for the Botany, Chemistry, Geology, Physics, Psychology and Zoology sections. There was no meeting of the Junior Academy but local chapters were encouraged to hold meetings. A ten dollar award was offered to the Junior Academy doing the most outstanding work during the year.

The total attendance was 116. The reports of the section chairmen are presented herewith in Table 1.

RECORD OF SECTIONAL ACADEMY MEETINGS WITH PAST AND FUTURE OFFICERS

Name of Section	Chairman for 1945	No. papers on program	No. persons attending	Chairman for 1946
Botany	Elva L. Norris	15	30	C. F. Gladfelter
Chemistry	Harry H. Sisler	11	26	Ruth Thompson
Geology	J. R. Chelikowsky	9	13	John C. Frye
Kansas Entomological Society	W. T. Emery	....	20	H. H. Walkden
Physics	P. S. Albright	3	12	G. W. Matthews
Psychology	Homer B. Reed	12	32	J. A. Glaze
Zoology	L. L. Loewen	23	40	Mary Larson

The following officers were elected for the year 1945-46: President, Dr. John W. Breukelman, Kansas State Teachers College, Emporia; President-elect, Dr. Claude W. Hibbard, University of Kansas; Vice-President, Dr. John C. Peterson, Kansas State College; Secretary, Dr. Donald J. Ameel, Kansas State College; Treasurer, Dr. F. W. Albertson, Fort Hays Kansas State College; additional executive council members, Dr. L. D. Bushnell, Kansas State College; Dr. H. H. Lane, University of Kansas; Dr. Paul Murphy, Kansas State Teachers College, Pittsburg; and Miss Edith Beach, Lawrence High School. Dr. Mary T. Harman and Dr. A. B. Cardwell, Kansas State College, were elected associate editors for a term of three years and Dr. W. H. Schoewe, University of Kansas, was elected to serve a two year term as associate editor of the Academy *Transactions*. Dr. M. J. Harbaugh, Kansas State College, was elected Academy librarian.

DONALD J. AMEEL, *Secretary*.

GENERAL PROGRAM

Seventy-Seventh Annual Meeting

Manhattan, Kansas

April 14, 1945

8:30 to 9:30—Council Meeting, Fairchild Hall, 202.

9:30 to 10:00—Registration, Anderson Hall.

10:00 to 11:00—Public lecture entitled "Recent Advances in Plant Science" by Dr. Walter F. Loehwing, Department of Botany, University of Iowa. This address was broadcast over Radio Station KSAC.

11:00 to 12:00—General Meeting, Anderson Hall, Recreation Center.

a. Call to Order, Academy President L. D. Bushnell.
b. Welcome, Dr. S. A. Nock, Director of Admissions, K.S.C.
c. Kansas Contribution to American Men of Science by H. E. Zabel, Clay-Adams Co.
d. Business Session.
e. Announcements.

12:15 to 1:45—Luncheon, College Cafeteria. Address of Retiring President Bushnell entitled "Micro-organisms and the Struggle for Existence."

2:00 to 4:15—Sectional Meetings.
Botany, Dickens Hall, Room 108.
Chemistry, Willard Hall, Room 115.
Geology-Physics, Willard Hall, Room 101.
Psychology, Education Hall, Room 204.
Zoology, Fairchild Hall, Room 102.
*Entomological Society, Fairchild Hall, Room 202.
Am. Assoc. Univ. Prof., Calvin Hall, Room 208.

4:15 to 5:00—Final Business Meeting, Anderson Hall, Recreation Center.

5:00 to 5:30—Meeting of New Council, Same Room.

***Entomological Society met at 11:00.**

BOTANY

Chairman, Elva L. Norris

2:00 p.m. to 4:15 p.m., Dickens Hall, Room 108

1. Perennial Wheat. L. P. Reitz, K. L. Anderson and C. O. Johnston, K.S.C.
2. Botanical Notes for 1944. Frank U. G. Agrelius, K.S.T.C., Emporia.
3. Nature and Rate of Development of the Root System of Climbing Milkweed, *Gonolobus laevis.* John C. Frazier, K.S.C.
4. Preliminary Studies on the Growth of *Stichococcus bacillaris.* Sister Crescentia Giersch, Marymount College.
5. Bindweed Development Under Different Degrees of Shading. John C. Frazier, K.S.C.
6. Comparative Yields of Forage from Native Grass and from Land Seeded to Native Grass at Hays, Kansas. Andrew Riegel, F.H.K.S.C.
7. Kansas Botanical Notes, 1944. Frank C. Gates; K.S.C.
8. Shoot-root Ratio and Moisture Relations. L. J. Gier, William Jewell College, Liberty, Mo.
9. Jack Rabbits as an Agency in Seed Dispersal of Native Plants. Leo Brown, F.H.K.S.C.
10. *Amphiachyris dracunculoides* as a Poisonous Plant. Frank C. Gates, K.S.C.
11. The Development and Germination of the Intraepidermal Teliospores of *Melampsorella cerastii.* S. M. Pady, Ottawa University.
12. Development of Adventitious Roots Inside the Trunks of Trees. L. J. Gier, William Jewell College.
13. Testing Fungicidal Properties of Saturants. Clinton C. McDonald, University of Wichita.
14. Belscamper's Work on Transpiration in Certain Kansas Weeds and Crop Plants. E. C. Miller, K.S.C. (By Title).
15. Aging of Plant Tissue and Stress-strain Curves, Modulus of Elasticity and Specific Gravity of Plant Tissues. Otto Treitel, Fisk University, Nashville, Tenn. (By Title).

CHEMISTRY

Chairman, Harry H. Sisler

2:00 p.m. to 4:15 p.m., Willard Hall, Room 115

1. A Study of Some Simple Hydrides. Frank Jirik, K.U.
2. Phosphate Fixation by Soil Minerals IV. Alfred T. Perkins, K.S.C.
3. The Use of Ionization Potential Data in Teaching Inorganic Chemistry. Harry H. Sisler, K.U.
4. A Preliminary Study of Possible Color Reactions for Aliphatic Compounds Using Vanillin in 1, 4 Dioxane. Jeane Haerle and Sister Ann Cecile Bauer, Marymount College.
5. Gaseous Phase Chlorination of Isobutane and Some of the Properties of the Resulting Substances. Robert Taft, Jr., and George W. Stratton, K.U.
6. Some Triazo and Pentazo Compounds. Carl E. Johnson and Ray Q. Brewster, K.U.
7. Nutritional Requirements and Sources of the Essential Amino Acids. D. B. Parrish, K.S.C.
8. Application of the Electronic Theory to Some Simple Organic Reactions. Calvin A. Vander Werf, K.U.
9. Oxidation-Reduction-Electron Transfer or Valence Number Change? Arthur W. Davidson, K.U.
10. Bacteriostatic Effect of Sulfasuxidine in Vitro and Antagonistic Influence of Carbohydrates upon Sulfanamides Action. Michele Gerundo, Univ. Calif. (By Title).
11. Synergism: Word of the Future. B. Ashton Keith, Washington, D. C. (By Title).

GEOLOGY - PHYSICS

Chairmen, J. R. Chelikowsky and P. S. Albright

2:00 p.m. to 4:15 p.m., Willard Hall, Room 101

1. North American Cephalaspids. George M. Robertson, F.H.K.S.C.
2. The Extent of the Pennsylvanian-Permian Disconformity in Pottawatomie County. C. H. Harned and J. R. Chelikowsky, K.S.C.
3. Shartons or Dust Spouts, the Most Dangerous Type of Dust Storm. B. Ashton Keith, Washington, D. C.
4. Fossils from the LaBrea Tar Pits in Kansas Museums. R. E. Mohler, McPherson College.
5. A Rare Cameloid from the Late Pleistocene Sands of Southwestern Kansas. E. S. Riggs, K.U. (By Title).
6. A New Locality for Fossil Rodents of the Rexroad Fauna. Claude M. Hibbard, K.U. (By Title).
7. Notes on the Howard Limestone. Walter H. Schoewe, K.U. (By Title).
8. Geology and Identification of Indian Artifacts. Walter H. Schoewe, K.U. and Charles G. Schoewe, Milwaukee, Wis. (By Title).
9. Fossils of the Vinland Marine Shale. Arthur Bridwell, Baker University. (By Title).
10. A Brief Report on the University of Wichita Foundation for Industrial Research. Penrose S. Albright. Univ. of Wichita.
11. Phonograph Record Waxes. Leroy Hughbanks, Osborne, Kansas.

PSYCHOLOGY

Chairman, Homer B. Reed

2:00 p.m. to 4:15 p.m., Education Hall, Room 204

1. Personality in Married Couples as Shown in Their Autokinetic Reactions. Albert C. Voth, Topeka State Hospital.
2. Testing for Leadership in Industry. Irvin T. Shultz, Friends University, and Bently Barnabas, Kansas Gas and Electric Co.
3. Visual Phenomena During Retinal Detachment. J. A. Glaze, K.S.T.C., Pittsburg.
4. Techniques Used in a Political Speech Campaign. Frances M. Ross and Edward W. Geldreich, K.S.T.C., Emporia.
5. A Comparison Between Counselor's Ratings and Test Scores of Students. Marion L. Saunders and Edward W. Geldreich, K.S.T.C., Emporia.
6. Climatic Changes and the Production Curve. Raymond H. Wheeler, K.U.
7. The Use of a Battery of Psychological Tests for Diagnosis of Maladjustment in Young Children—A Case Report. Sibylle K. Escalona, The Menninger Clinic, Topeka.
8. The Relationship of the Nutritive Value of Butter and Corn Oil Fats to Learning Ability of Rats. E. Roberta Shimer, J. S. Hughes, O. W. Alm, and D. B. Parrish, K.S.C.
9. Analysis of Scatter in Intelligence Test Results—A Review of the Literature. Martin Mayman, The Menninger Clinic, Topeka.
10. Some Aspects of the Diagnosis of Delinquent Children. Bert A. Nash, Kansas Receiving Home for Children.
11. The Learning and Retention of Concepts: II. The Influence of Length of Series. III. The Origin of Concepts. Homer B. Reed, F.H.K.S.C.
12. An Analysis of Responses in Non-directive Counseling. Anne E. Royer, Wichita Guidance Center.

ZOOLOGY

Chairman, S. L. Loewen

2:00 p.m. to 4:15 p.m., Fairchild Hall, Room 102

1. Dental Caries in Bears. E. Raymond Hall, K.U.
2. Rodent Activity in the College Pasture Near Hays, Kansas. Leo Brown, F.H.K.S.C.
3. Observations on Abnormal Anatomy of Two Headed Calf. L. J. Gier, William Jewell College, Liberty, Mo.
4. Comparative Anatomy of the Intestinal Tract of North American Cricetine Rodents. Donald F. Hoffmeister, K.U.
5. A New Host Record for *Bothridium pithonis* Blainville (Cestoda). S. L. Loewen, Tabor College.
6. Soybean Oil Meal Versus Meat Scrap Supplement in Maintenance of Animal Resistance to Parasitism. B. B. Riedel and J. E. Ackert, K.S.C.
7. A Comparative Study of the Proventriculus of a Species of Woodpecker, Dove and Meadowlark. Leon G. Lungstrum, K.S.C.
8. The Postnatal Development of a Brood of Great Horned Owls, (*Bubo virginianus virginianus*). Henry W. Setzer, K.U.
9. A 350 Million Year Old Brain-case. George M. Robertson, F.H.K.S.C.

10. Cephalization in the Central Nervous System of Vertebrates. Homer B. Latimer, K.U.
11. Tensile Strength of Tissues as Influenced by Male Sex Hormone. E. H. Herrick, K.S.C.
12. Seasonal Food Choices of the Fox Squirrel in Western Kansas. Robert E. Bugbee, Indiana Univ. and Andrew Riegel, F.H.K.S.C.
13. The National Roster with Special Reference to Biologists. Roger C. Smith, K.S.C.
14. Comparative Damages Done by Voles and Other Animals to a Field of Late-standing Kansas Corn. B. Ashton Keith, Washington, D. C.
15. Grouse Locust Cytogenetics. Orthoptera: Acrididae: Subfamily Tetriginae. Robert K. Nabours and Florence M. Stebbins, K.S.C.
16. Disappearing Towns. B. Ashton Keith, Washington, D. C.
17. Mexican Amphibians and Reptiles in the Texas Cooperative Wildlife Museum. Hobart M. Smith and Leonard E. Laufe, Univ. of Rochester, Rochester, N. Y. (By Title).
18. Spermatozoon Transformation in the Big Cockroach. W. J. Baumgartner, K.U. (By Title).
19. Ecological Comparisons of the Plains Prairie Dog and the Zuni Species. Theo. H. Scheffer, U. S. Biol. Survey, Puyallup, Washington. (By Title).
20. Contributions to the Herpetology of Texas. VIII. Some Frogs and Toads. Charles E. Burt, Topeka. (By Title).
21. A Report on Some Amphibians and Reptiles from Louisiana. Charles E. Burt, Topeka. (By Title).
22. Mammalian Remains from an Indian Midden in Saint Clair County, Missouri. M. Maldonado-Koerdell, K.U. (By Title).
23. Papillid Snails from the Sanborn Area of Northwest Kansas. Dorothea S. Franzen and A. Byron Leonard, K.U. (By Title).

CONSTITUTION AND BY-LAWS
As Amended and Revised On April 14, 1945

Constitution*

SECTION 1. This association shall be called the Kansas Academy of Science.

SEC. 2. The objects of this Academy shall be to increase and diffuse knowledge in various departments of science.

SEC. 3. The membership of this Academy shall consist of three classes: annual, life and honorary.

(1) Annual members may be elected at any time by the committee on membership, which shall consist of the secretary and other members appointed, annually, by the president. Annual members shall pay annual dues of one dollar, but the secretary and treasurer shall be exempt from the payment of dues during the years of their service.

(2) Any person who shall have paid thirty dollars in annual dues, or equivalent due to legal exemption, or in one sum, or in any combination, may be elected to life membership, free of assessment, upon recommendation by the membership committee and a majority vote of those attending the annual business meeting of the Academy.

(3) Honorary members may be elected because of special prominence in science by being nominated by at least two Academy members in good standing, the nomination being submitted in writing to the membership committee for approval and recommendation to the Academy at its annual meeting. A two-thirds vote of all members present at the annual business meeting shall constitute election. Honorary members pay no dues.

SEC. 4. The officers of this Academy shall be elected at the annual meeting, and shall consist of a president, the president-elect, a vice-president, a secretary and a treasurer, who shall perform the duties usually pertaining to their respective offices. The president, the secretary and the treasurer shall constitute the executive committee. The secretary shall be in charge of all the books, collections and material property belonging to the Academy except those provided hereinafter in the Constitution and By-Laws.

SEC. 5. Unless otherwise directed by the Academy, the annual meeting shall be held at such time and place as the executive com-

*The changes made in the Constitution and By-Laws as published above can be determined by comparison with the last previously published copy. (See these *Transactions*, vol. 43, p. 7 (1940).)

mittee shall designate. Other meetings may be called at the discretion of the executive committee.

SEC. 6. This Constitution may be altered or amended at any annual meeting by a vote of three-fourths of attending members of at least one year's standing. No question of amendment shall be decided at the business meeting of its presentation.

SEC. 7. This Academy shall have an executive council, consisting of the president, the president-elect, the vice-president, the secretary, the treasurer, the retiring president, the editor, the managing editor, and three other members to be nominated by the nominating committee and elected in the same manner as the other officers. This council shall have general oversight of the Academy not otherwise given by this Constitution to officers or committees.

SEC. 8. The official publication of this Academy shall be known as the *Transactions of the Kansas Academy of Science* and authority is hereby granted its editor and managing editor to publish said *Transactions.* The official publication shall be issued annually, quarterly or at such other intervals as shall be decided upon by the editorial board and executive council.

SEC. 9. The editorial board named in section 8 shall consist of an editor, an assistant editor, a managing editor, and five associate editors. The members of this board shall be selected to include representatives of the major fields of science and, with the exception of the assistant editor, shall be elected in the same manner as other officers of the Academy but for a period of three years.

The editor shall be the officer of the editorial board directly responsible to the Academy for the publication and conduct of the *Transactions;* he shall be the chairman and executive officer of the editorial board and at his discretion may appoint an assistant editor, whose term of office shall be coincident with that of the editor, and whose duty it shall be to assist the editor in his duties. The editor, together with other members of the editorial board shall form the editorial policy of the *Transactions* including the selection, revision and editing of papers submitted to the *Transactions.*

The managing editor, working with the editor, shall be responsible for the business management of the *Transactions,* including the making of publication contracts, the ordering of cuts and supplies, the distribution of the *Transactions,* the securing of advertising (if desirable), and the securing of publicity and of increased circulation for the *Transactions.*

By-Laws

I. At the beginning of each annual session there shall be held a brief business meeting for announcements and appointment of committees. For the main business meeting, held later in the session, the following order is suggested:

1. Reports of officers.
2. Reports of standing committees.
3. Unfinished business.
4. New business.
5. Reports of special committees.
6. Election of officers.
7. Election of life and honorary members.

II. The president shall deliver a public address at one of the general sessions of the annual meeting.

III. No annual meeting shall be held without a notice of the same having been published in the papers of the state at least fifteen days previously and the membership informed of the date and place of the meeting by the secretary.

IV. No bill against the Academy shall be paid by the treasurer without an order signed by the president and secretary.

V. Names of members more than one year in arrears in dues shall be dropped from the membership list.

VI. Ten percent of the active membership shall constitute a quorum for the transaction of business. Section meetings may not be scheduled or held at the time a business meeting is called by the president at a general session or announced on the program.

VII. The time allotted to the presentation of a single paper should not exceed fifteen minutes unless extended time is granted by vote of the section. Presidential addresses and those of guest speakers, as well as special invitation papers read by members, are without time limit.

VIII. Section programs may be arranged by the secretary with the advice of the section chairman. The subdivision or combination of existing sections shall be dependent upon the number of papers to be presented. Such changes shall be made by the secretary in accordance with the policies of the Academy and after receiving the advice of the chairmen of the sections concerned.

IX. Section chairmen for the ensuing year shall be elected annually at the close of the section meetings.

X. Section programs may be held at any time of the annual session except during the time devoted to the business meetings and general sessions.

XI. Academy members, not in arrears in dues, have the privilege of submitting papers for publication in the *Transactions* to the editorial board. The editorial board, however, shall have the right to solicit papers by invitation from any author, irrespective of the author's membership in the Academy.

Featured Reviews in These Transactions Have Appeared or Will Appear as Follows:

SEPTEMBER, 1944—THE CROP INDUSTRIES OF KANSAS, Dean L. E. Call, Kansas State College.

DECEMBER, 1944—THE FOSSIL VERTEBRATES OF KANSAS, PART I, Dr. H. H. Lane, University of Kansas.

MARCH, 1945—KANSAS WILDLIFE CONSERVATION POLICIES, Dr. E. O. Stene, University of Kansas.

JUNE, 1945—THE COLORADO DESERT OF CALIFORNIA, Dr. T. D. A. Cockerell, University of Colorado.

SEPTEMBER, 1945—RECENT ADVANCES IN THE PLANT SCIENCES, Dr. W. F. Loewhing, University of Iowa.

DECEMBER, 1945—RECENT ADVANCES IN APPLIED NUTRITION, Dr. E. V. McCollom, Johns Hopkins University.

MARCH, 1946—THE GEOGRAPHY OF KANSAS, Dr. W. H. Schoewe, University of Kansas.

JUNE, 1946—THE KANSA INDIANS, Dr. W. R. Wedel, Division of Archeology, U. S. National Museum, Washington.

SEPTEMBER, 1946—RECREATIONAL AREAS IN KANSAS, Dr. E. O. Stene, University of Kansas.

Transactions
Kansas Academy of Science

Volume 48, No. 2 September, 1945

Recent Advances in the Plant Sciences

W. F. LOEHWING
Professor of Botany, University of Iowa, Iowa City

It is with pleasure that we present this interesting and important review prepared by a distinguished botanist from our sister state. In its original form, the review was broadcast over stations KSAC and WIBW at the seventy-seventh annual meeting of the Academy held at Manhattan on April 14, 1945. For further information concerning the author, see page 136.—THE EDITOR.

The exigencies of war have confronted America with a sudden food crisis. The military decision to safeguard the fruits of victory by giving sustenance to liberated nations now entails a serious drain upon our agricultural resources. Though 25% of civilian food or nearly 50% of our calorie intake has already been rationed, we are admonished to tighten our belts still further. Complaints about present restraints of rationing are rapidly developing into serious concern about the future. We are conscious of radical modifications in the American dietary but we do not generally know all the important reasons for them.

The present problem is clear cut. If America is to meet the commitments already made to help our war-stricken allies surmount the indescribable chaos inherent in the early period of rehabilitation, our already strained agricultural production must be still further increased. This can be achieved only by abandonment of the luxury items of our diet in favor of equally nutritive foods which can be

Transactions Kansas Academy of Science, Vol. 48, No. 2, 1945.

more rapidly produced in large amounts. The necessary shift is certainly not in the direction of a starvation diet. In fact, reliable statistics indicate that the civilian now eats on the average ½ pound more of food per day than before the war.[10] Admittedly our foods are changing in the direction of more vegetable proteins and fats in place of meat. Though the palatability of our diet is diminishing, its nutritive and health values are not. It is well known that vegetable foods can support a larger population than livestock produced on a comparable acreage.

As we now survey the awful wreckage of war, we begin to grasp the full significance of the statement that "food will win the war and write the peace". To the soldier, victory brings well-earned release from carnage and indescribable sacrifice. The awesome silence of peace is however, already broken by the pitiful pleas of countless thousands of liberated peoples who now cry for food. In the hour of victory, American farmers are being called upon to redouble their efforts, to supply at once the food needed by those who would otherwise starve and to produce quickly those other commodities of farm and field needed to bind the wounds of suffering humanity. In war, fate gave us time to forge the weapons of victory but in peace the hunger of liberated peoples can brook no delay. Without food immediately and in abundance, the dearly won fruits of victory may well wither in our very hands and peace may be transmuted into a world chaos as frightful as war itself. The posibility of such an occurrence has fortunately been recognized by our military and political leaders and they have taken many steps to prevent it by safeguarding the uninterrupted flow of agricultural commodities. The American public is being asked by our government to cooperate by acceptance of a temporary modification of its diet and thus help to insure a durable peace commensurate with the unprecedented sacrifices made to achieve it.

Though the advances of agriculture and biological sciences under the stimulus of war are not generally as well known as those in industrial technology, they have, nevertheless, been numerous and will play an increasingly important role in the normal pursuits of peacetime life. As in industry, the problems in agriculture and plant science are not only those of increased production, but of meeting new and crucial needs in a shifting world order. A review of achievements is both enlightening and gratifying.

The shortage of rubber still continues to be a serious problem. The impact of the rubber crisis upon agriculture is reflected in statistics on the quantity of alcohol now produced from agricultural materials for the manufacture of rubber substitutes. In 1940 only 13% of the alcohol produced in America was manufactured from cereals and other vegetable sources. In 1944, 68% of our greatly enlarged supply of ethyl alcohol was produced from cereals, cull potatoes, sugar beets, waste sulphite liquor from our paper mills and many other plant products.[1, 7, 13, 19] Though the petroleum industry still plays a dominant role in the manufacture of synthetic rubber, rubber substitutes derived from vegetable sources are, nevertheless, becoming increasingly important. A notable recent advance has been the commercial production of high grade rubber substitutes from soybean oil by a means of a process developed by the Regional Laboratories of the United States Department of Agriculture.[18, 19] This is but one of the many new uses for soybeans initiated in recent months. It seems safe to predict that synthetic rubber is here to stay and that America will never again be wholly dependent upon foreign supplies.

The United States, Regional Agricultural Laboratories have also developed a process for the manufacture of an artificial wool from soybean meal. The new product, already in commercial production, compares favorably with sheep wool for blankets, felt, upholstery and suiting fabrics.[8] In the hands of scientists, the soybean continues to be the Alladin's Lamp of American agriculture. Soybeans now also serve as a major source of edible oils and food pastes which are being used as meat substitutes. In 1944 Lend-Lease alone, apart from Army, Navy and domestic civilian use, purchased over one million pounds of American soybean flour and grits for our military allies.[3, 10] The perfect way in which soybean meal meets the requirements of a nutritive diet, its ease of transport and storage have led to the export of most of America's production and left those of us at home as yet largely unaware of the unique place which soy products have already asumed as human food.[10] Soy bean products now also have a prominent place as meat substitutes in the so-called K ration of the armed forces.

In order to make this meat substitute as acceptable as possible, soy meal is being treated with a salt of glutamic acid to provide the flavor and aroma of a well-grilled meat. We are endeavoring to simulate with vegetable products the meats to which we have so

long been accustomed. The use of soybeans for many other products than food is increasing on a phenomenal scale. The manufacture of soybean plastics and adhesives as well as many other new uses added to the earlier importance of soybeans as a soil building crop and stock food, have already put the importance of this comparative newcomer to American agriculture on a par with cotton and cereals in our national economy.[8, 10]

While dwelling on the subject of meat shortages, certain misgivings about the immediate future might be allayed by mention of two other projects designed to alleviate this particular crisis. Considerable publicity has of late been given food yeasts. In mass production these yeasts promise to achieve an important place as meat substitutes and protein supplements in our diet by virtue of their palatability and high nutritive value. These yeasts contain 50% protein and are high in B vitamins. They can be grown cheaply and in huge quantities on a mixture of molasses and ammonium salts. We are told that the molasses from one acre of sugar cane will produce 840 pounds of food yeast while livestock feed from an acre of farmland will yield only 70 pounds of protein as meat or milk.[16] Food yeast production is now already underway in American breweries but the output is thus far largely employed as livestock and poultry feed. The use of yeast proteins in powdered and dehydrated foods is now increasing rapidly.

Though the reader may feel a bit skeptical about the future role of soybean flour and food yeasts as meat substitutes, there is however, now in use a practice of which we all have been the beneficiaries, though perhaps unknowingly. At present, naturally, attempts are made to use all possible meat as human food with the result that much over-age beef which ordinarily would have been diverted to other purposes now finds its way to our tables. Some of our own personal encounters with point-free, utility cuts of beef will probably suffice as a description of tough meat. Bad as this situation is, over-age beef would be a lot tougher if not commercially treated with an enzymatic extract of papain obtained from papaya fruits. The papaya is a melon-like, semi-tropical fruit obtained from Texas and Florida which yields copious amounts of an enzyme capable of rapidly digesting the connective tissues which make old meat tough. The enzyme papain is easily extracted from the fruit and its use in the present meat crisis has certainly salvaged for use as reasonably palatable steaks many tough cuts of old beef

which otherwise would have been converted to hamburger or even less dignified comestibles.

Such achievements of farmers and laboratory scientists have been matched by those of our foresters and horticulturists. The southern states possess vast acreages of so-called slash pine for which they have long sought a profitable use. Small pine trees are of comparatively little value as a source of rosin or turpentine and up to the present time they have not been used in the manufacture of paper pulp because of their resin content. Only broad-leaved trees and a few species of non-resinous evergreens in our northern states and Canada have heretofore been adapted for manufacture of paper pulp. Because of this our largest pulp mills were located in the north and in Canada. Recently the Herty process for the rapid elimination of resin from small trees of southern slash pine has been perfected, thus finally making our huge reserves of these trees available as a source of paper pulp. The establishment of pulp mills in the south has resulted in a great new agricultural industry in the southern states. Perfection of Herty process has already proven a boon to the hitherto impoverished region of the pine barrons and it promises to make America largely independent of the more costly foreign sources of paper pulp. Without this new source of paper pulp our present shortage of newsprint would be much more serious.

The output of the so-called naval stores, such as turpentine and resin obtained on a large scale in our southern states, has been greatly increased by a recently perfected method of propagating particularly high yielding trees by means of cuttings taken from vigorously growing stems. Reproduction of pine trees by seed is slow and seeds from high yielding trees do not always produce good progeny. By means of certain growth stimulants such as indole butyric and alphanaphthylene acetic acid, it is now possible to induce cuttings taken from especially good pine trees to strike root. This procedure insures the propagation of only the highest yielding trees and shortens the time required for such young trees to become productive. Another recent development of tremendous importance has been the perfection of a process of treating plywoods with urea. Heat applied to wood veneers impregnated with urea renders them soft and pliable. The impregnation of wood veneers with urea and hot bonding agents and plastics has permitted the molding of plywoods into many desired shapes, thicknesses and strength. A striking use of such plywoods is found in the British Mosquito bombing planes.

These plywood planes are cheap, light in weight and hence have long flying ranges as well as low operating costs. Wooden airplane parts do not readily coat with ice and are more shatterproof than metal to shell explosions. Plastic impregnation and urea treatment entirely alters the natural characteristics of wood and greatly improves its utility. Cheaper grades of soft woods such as pine or poplar when impregnated with plastics are converted into acceptable substitutes for our dwindling supplies of high grade hardwoods such as oak and maple used for furniture and interiors.

Urea recently has also made an important place for itself as a feed supplement for dairy cattle. In the current feed shortage in dairy states, urea is being successfully fed as a protein substitute to maintain high milk production. The feeding of urea along with the very nutritious new variety of clover known as Ladino has contributed substantially to maintenance of dairy supplies. In regions of its cultivation in New England, Ladino clover alone has been credited with surprisingly large increases in milk yield.[14]

The use of numerous new chemicals to control the behavior of plants in various ways has been one of the outstanding agricultural developments of recent years. Most interesting and useful among such substances have been the so-called hormones or growth substances which produce marked plant responses at surprisingly low concentrations. Only a few parts per million of these chemicals dissolved in water or dispersed in powders such as talc and other dusts need be used to induce the rooting of cuttings from many different

FIG. 1. Seedless tomato. A. Seedless fruit formed from blossom treated with 5 ppm of indole butyric acid in lanolin. B. Control fruit with seeds formed from blossom treated with pure lanolin.

types of plants hitherto impossible to propagate otherwise. This procedure has been of special importance in propagation of evergreen,

citrus, maple, pear, and many types of ornamentals. Related chemical compounds can be used to set fruits and to make them seedless.[12] Seedless tomatoes and other fruits of improved quality can be produced either by spraying flowers with solutions of indole butyric acid or by use of vapors of beta-naphthoxy-acetic acid.[2] Seed and garden catalogs for this year are advertising such sprays to home gardeners. Sprays containing naphthalene acetic acid have also been a boon to apple growers in preventing premature fruit drop. Commercial sprays which cause young apples to set on trees have now been perfected. By controlled application of the second spray after young apples have set, a certain proportion of them can be induced to drop off, thus improving the size and quality of those which remain.

An unexpected military application was found for the so-called "stay-on" sprays used to prevent fruit drop. Such sprays also prevent leaf-fall. Natural vegetation used as camouflage soon sheds its leaves which necessitates continuous replacement. Surrounding vegetation is so rapidly depleted in this way, that camouflaged installations in a denuded area eventually become suspiciously conspicuous and draw fire. Foliage sprayed with naphthalene-acetic acid and related compounds before cutting, not only retains its leaves but these remain green even though withered. A single covering with such treated foliage lasts a long time and overcomes the difficulties inherent in the use of unsprayed vegetation. Artificial foliage and similar synthetic materials are often not very satisfactory nor available for camouflage and they are frequently detectable by means of special films used in reconnaisance cameras. Defoliation sprays of a directly opposite type cause leaves to fall off and such chemicals are now being used commercially to facilitate harvesting of soybeans and cotton bolls.[5, 9]

Ethylene gas continues to be used with great success in the marketing of fruits. In low concentrations, ethylene acts as a bleach to remove the green color of fruits. It also accelerates enzymatic processes which convert starch to sugar and remove the organic acids responsible for the tart flavor of unripened fruits. From a practical standpoint it is now possible to harvest certain tree fruits somewhat earlier and thereby reduce the perishability of tree-ripened products, which in turn effects a commensurate reduction in prices paid by the consumer. Artificial ripening by means of

ethylene has been used especially effectively on citrus fruits, particularly on lemons.

Studies of ethylene incidentally revealed that certain fruits, such as apples, produce this gas in small amounts naturally. This discovery proved to be of practical importance in relation to apple and pear storage. These fruits generally undergo considerable deterioration during storage throughout the winter in commercial warehouses. The suspicion arose that when apples were closely packed in barrels, they might be stimulated to over-rapid ripening by means of their own ethylene emanations. Experiments verified this suspicion and provision is now made to ventilate warehouses occasionally or to expose barreled apples to a vacuum in order to draw off the ethylene, thus improving the keeping qualities and permitting longer periods of storage.

In recent years, many new and important plants have appeared on the American scene. Prior to the war, cork bark from Spain was our major source of insulating and buoyant materials. Our dependence upon entirely foreign sources has proved so embarrassing that cork oak production has now been successfully undertaken on a commercial basis in California. Supplementing the wholly inadequate supply of cork as the insulating and buoyant component of life preservers and aviators clothing, we now have milkweed floss in commercial production. The silky floss around milkweed seeds carries a natural wax which makes it resistant to wetting by water and protects it against mildew. Floss fibers also contain large air-pockets which gives them great buoyancy and excellent insulating properties against cold. Practically the entire output of milkweed floss has until recently been purchased for the United States Navy. The proven value of milkweed floss is attested by the government sponsored collection of milkweed pods by America's school children.

An agricultural development of great importance in the midwest has been the production of coarse fibers used for heavy hawser ropes and marine packing. They are produced from the common hemp plant. This native weed, otherwise known as marihuana, is marketed only under authority of federal license because of its possible illicit use as an opiate in reefer cigarettes and smoking tobaccos. The erection of hemp processing factories in the midwest was authorized by act of Congress as a war measure and their output was largely purchased by the Commodity Credit Corporation at prices as high as $10 per bushel for seed and $40 per ton for first

grade hemp straw. The transfer of hemp production to our northern states has given them a new agricultural industry already valued at millions of dollars.

Probably the most important and certainly the most dramatic of recent biological discoveries is that of the drug penicillin, produced by the common green mold, *Penicillium notatum*. The appearance of penicillin in the midst of war has proven providential for

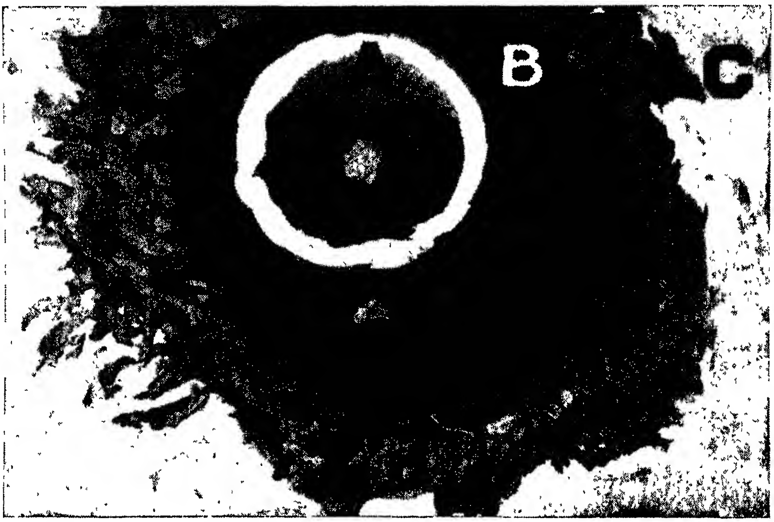

FIG. 2. Culture showing antibiotic effect of Penicillium notatum mold. A. Mycelial mat of mold from which the exudate of penicillin has prevented growth bacterium in the dark area; B. Bacterial growth shown at margin in white.

the United Nations. The rapidity of its perfection as a drug and the acceleration of its production are truly miracles of modern biological science comparable to those in radio, electronics and aviation. This drug is the almost ideal specific for treatment of many diseases against which sulfa drugs are not efficacious. In the case of certain grave diseases its bacteriostatic action is incredibly swift. Victims of speticemias, who without penicillin would have lived but a few hours, have been cured in a matter of days by penicillin. It is effective against gonorrhea, osteomyelitis, boils, incipient syphilis and several types of pneumonia. Penicillin possesses the virtue of being effective against certain acute as well as chronic diseases, and its utilization is remarkably free from the complicating side-reactions known among sulfa derivatives. The patient, or more exactly the bacterial pathogen, does not develop a marked tolerance or im-

munity to repeated use of the drug, with the result that moderate doses continue to be effective throughout its administration. Unlike sulfa drugs, the use of penicillin does not cause severe nausea or nervous distress.

As a result of foresighted subsidy by our federal government, mycologists, physicians, chemists and industrialists all cooperated diligently in research and production of penicillin. The initial investment of 3 million dollars made in 1943 for increase in facilities for its production has already been largely amortized. The cost of the drug has been reduced to one-tenth of its original price, and penicillin is now available to civilian hospitals throughout the entire nation as well as to all troops of the United Nations. In the past few months, methods have been perfected for its preservation, a discovery which will increase the quantity available and further reduce its cost. The chemical composition of penicillin has recently been determined, a fact which may permit its early artificial synthesis with commensurately larger output at a still lower price. Penicillin has been so effective against human disease that attempts are now being made to use it and related compounds as plant sprays to control plant diseases caused by bacteria similar to those causing human disorders.

In the area of medicine there have also been two other new plant products which have become of clinical importance. For many years it was known that a hemorrhagic disease and internal bleeding occurred in livestock heavily grazed on clover. Analysis of clover plants disclosed that they contained a chemical known as dicoumarin which in large amounts causes serious hemorrhage but in smaller amounts merely prevents blood from clotting. This chemical is now commercially available and can be employed medicinally to prevent operative and post-parturient embolism, thus reducing some of the hazards of surgery and child-birth. The antithesis of dicoumarin is found in vitamin K or naphthaquinone which occurs normally in alfalfa. Vitamin K induces clotting of blood and thus has a physiological action which is the diametric opposite of that induced by dicoumarin. Vitamin K has been crystallized in pure form and is now also available as a drug employed to prevent excessive bleeding from wounds and, perhaps far more important, to reduce internal hemorrhage such as occurs in certain diseases.

I also wish to mention an alkaloidal drug, colchicine, which has in recent years been much publicized as a means of producing new

varieties of plants, especially among ornamentals. It is highly advertised in garden and popular magazines and its use has provided an interesting hobby for amateur gardeners. As commonly used, its effects are quite unpredictable though a number of interesting new varieties have been produced in this way. Scientific techniques for its use on valuable but sterile hybrids are now yielding encouraging practical results which give promise of epoch-making improvements in important crop plants. When two varieties are hybridized to combine in a single offspring the desirable traits of two parents, such progeny usually show hybrid vigor but they are also often sexually sterile. Thus, unless such sterile hybrids can be vegetatively propagated by means of cuttings, grafts or bulbs, they are lost because of failure to produce seeds. The genetic machinery of such sterile hybrids can be so altered by colchicine as to restore fertility and at the same time retain all the desired traits, including hybrid vigor. The genetic alteration by means of colchicine involves a doubling of the chromosomal make-up of the plants which not only restores fertility of desirable hybrids but causes them to breed true from seed. In contrast to the usual segregation of fertile hybrids which complicates or prevents fixation of desirable traits, the colchicine-treated plants present the startling genetic paradox of a hybrid which breeds true. In the parlance of plant breeders, such true-breeding hybrids are called polyploids. Wheat and oats are naturally occurring polyploids but many other species, especially of ornamentals, also exist as polyploids, many of which have been experimentally produced. Various other drugs and new methods are now being used to produce true-breeding polyploid hybrids. Scientifically used, these procedures provide plant breeders with possibilities of far-reaching practical improvements in our major crop plants. Ability to produce true-breeding polyploid hybrids places in the possession of man a potential control of plant evolution and ability to produce new agricultural species better suited to our needs. The list of such polyploid types is already a long one, including improved commercial varieties of hemp, American timothy grass, peaches, loganberry, laxtonberry, Sea Island cotton, tobacco, wheat, tulips, hyacinths, asters, delphinium and other varieties too numerous to mention.(6, 11, 17, 20, 21) Wholly unrelated plant genera such as the cabbage and the radish have been crossed and induced to yield fertile and true-breeding progeny. Unfortunately the hybrid between them has neither the large leafy top of the cabbage nor the fleshy

root of the radish. But plant breeders have learned from past experience that something good often comes from just so discouraging a result as a seemingly useless cabbage-radish hybrid. At any rate,

FIG. 3. Colchicine induced mutation of tomato. Leaves, flowers and young fruits of comparable age of the normal diploid plant (2n) and of the tetraploid produced by colchicine (4n).

such a hybrid is something new, not merely a new species, but a new plant genus developed by man. The experimental production of new genera was considered impossible fifty years ago.

I have already referred to the timeliness of the discovery of penicillin and its spectacular role in the war. I cannot forego mention of an equally momentous botanical development during World War I. As late in the last war as January, 1918, the Federal Farm Loan Commissioner after an inspection tour of the European war zone advised our government that "unless more wheat could be raised in this country and shipped to Europe, it is a question whether our Allies can continue to wage the war". Somewhat prior to that date Kansas had developed a highly productive new wheat from the P-762 strain of Turkey Red which had theretofore been the dominant variety in the winter wheat belt of America. The new variety, called Kanred, soon made history throughout the world.[4] Its remarkable productivity was a major factor in overcoming the food crisis of the last war. Kanred wheat made Kansas and the entire winter wheat belt prosperous because wheat was then selling at two

dollars a bushel. By means of Kanred wheat, Kansas established a record which is still one of the epochal achievements of agricultural research. Kansas State College also started a new fashion by adroitly giving the name "Kanred" to the new wheat variety. The name made Kansas famous throughout the world, and the custom of naming new plant creations with the state of their origin is now established practice.

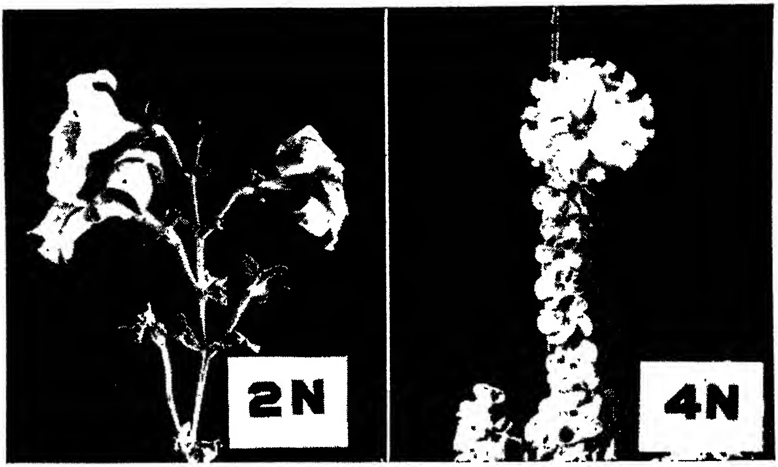

FIG. 4. Polyploid mutation of petunia produced from a traumatic callus. Normal diploid, single flowered plant (2n) and tetraploid mutant resulting from callus (4n). The tetraploid 4n plant has no leaves and is semi-double flowered. The calices of flowers are persistent and replace the leaves for purposes of photosynthesis.

But Kansas has not been content to rest upon her well-earned laureals. The oat variety developed at Manhattan under the name of "Kanota" was well known far beyond the prairies of Kansas. And again in this war, Kansas has come to the fore in public service. World War II abruptly cut off America's supply of tapioca from the tropics, upsetting the adhesive and paper industries as well as depriving us of tapioca pudding. Iowa, Texas and Kansas vied with one another to find a substitute for tapioca. Kansas has won the blue ribbon by finding the most desirable substitute for tapioca.[15, 18] And surprisingly enough, this substitute is obtained from a strain of waxy sorghum developed in this state. Once again the agriculturists of Kansas have met a serious war emergency by creating a new plant variety in a remarkably effective and ingenious way. Thousands of acres are now producing the waxy variety throughout the Great Plains region and in the corn belt.

The foregoing examples reflect the skill and unremitting exertion of our farmers and scientists. Such advances make it evident that the war has stimulated research in the plant sciences and in agriculture fully as much as in industry. For the time being, the untiring efforts and wholehearted cooperation of farmers, biologists and industrialists are geared in a remarkably efficient manner to the success of our war effort. With the advent of peace, however, it seems safe to predict that all mankind will be the beneficiary of our improved knowledge of biology in general. The advance in our knowledge and use of plants of all sorts has been largely for humanitarian purposes even in time of war. In peace, the new developments in agriculture will help alleviate the ravages of war. They will help to feed, clothe, house, restore to health and self-respect the millions of destitute among our allies. It will be fortunate indeed if the present collaboration between farmers, scientists and industrialists which has contributed so greatly to the success of the war effort might be perpetuated after total victory comes.

A new world order is now being shaped in the furnace of war. Domestic as well as international adjustments must be made. It becomes the responsibility of plant scientists not only to identify and to anticipate human needs, but to be especially alert now to possible practical applications of their discoveries in agriculture, medicine and the enrichment of the American way of life. Progress on problems which have emerged to date in this field of scientific study has been gratifying and plant scientists hope to acquit themselves even better in peace than they have during the war in their responsibilities to the American public.

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The Editor's Page

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ROBERT TAFT, *Editor*

One of my realistic colleagues states "Your editorials on the social responsibilities of the scientist appearing in several past issues of the *Transactions* were all very well. I agree with the thoughts expressed. Although they sound very well, aren't they general and vague? How do you propose that scientists shall acquire a sense of social responsibility?" The point is a good one and one that I hope to expound in somewhat greater detail as time and opportunity permit.

The first concrete suggestion that I would suggest in acquiring a sense of social responsibility is this: Obtain all the knowledge that your leisure permits of the region in which you live. Kansans live in a part of the trans-Mississippi plains and prairie states, a region that has many cultural similarities. Knowledge of these similarities and of differences is, to my mind, of basic importance in understanding this region and in creating a feeling of obligation toward it. Such knowledge is not the end in itself but rather it is the application of this knowledge to our present and future problems that makes it of greatest value.

The knowledge to be acquired is not only that of scientific work and workers in this general region, and in Kansas in particular, but the acquisition of trustworthy information on tradition, history, institutions, geography, industries, arts, politics and politicians, humor — all of those characteristics that go to make up our so-called culture. I have more than once been astonished at the lack of such knowledge in many who have lived in the state for years. Some of these individuals were even supported by the state and were counted among its leaders.

First hand knowledge of part of our culture is available to many of us, but even for the best informed additional study and understanding must be acquired through secondary sources.

What sources of information, then, can be utilized in acquiring such knowledge, especially knowledge that can be self-acquired? Fortunately, in recent years

there has been a growing interest and consciousness among publishers of the importance of regional literature.

For example, three comparatively recent series of books of value in this connection may be cited: 1) The *American Guide Series,* written by workers of the writers' program of the W.P.A. and called by one eminent critic of American life "the finest contribution to American patriotism that has been made in our generation." Volumes on Kansas, Nebraska, Oklahoma and Colorado are all available in this series; 2) the *American Folkway* series which includes a number of volumes on various parts of the western country including *Short Grass Country* by Stanley Vestel, the volume dealing most specifically with the Kansas region. The editor's favorites of this series, however, are *Pinon Country* by Hamil Long, a well balanced account of the historic, geographic and social features of northern New Mexico and Arizona and *Mormon Country* by Wallace Stegner; 3) *The Rivers of America Series,* including *The Kaw* by Floyd Streeter of Fort Hays Kansas State College, *The Missouri* by Stanley Vestal and *The Arkansas* by Clyde Brian Davis. Other individual volumes, many of which are more scholarly—but less readable—than any in the three series cited above, could be mentioned but their discussion must be reserved for future editorials.

It seems appropriate, however, in closing this editorial to call attention to our most important periodical of Kansas history and culture, *The Kansas Historical Quarterly.* To cite but a single instance of its value to the editor, I should like to mention an article appearing in a recent issue (February, 1945) written by Miss Alberta Pantle. It deals with the settlement in 1874 of the Russian Mennonite colony at Gnadenau, Marion County, some two miles from the present town of Hillsboro, Kansas. As the editor read the article and noted the list of the colony's founders, the names of Pankratz, Harms, Friesen, Groening and others were familiar ones, for the descendants of these colonists had either been students of the editor or were those with whom he has had various other associations. Understanding, admiration and knowledge of my friends were vastly increased as I read the revealing story of their forebears, their trials and courage, their successes and their humbleness of spirit and their eventual transformation into Kansans and Americans.

* * *

The above editorial was written some months ago. The developments of the past week—I am writing August 14th—might seem to call for some special effort of mine. I am willing, however, as I re-read my leading comments in the last three issues —and in this one—to let my case rest for the moment. I wish, however, to add one more observation by way of emphasis. Professor Albert Einstein, some seven or eight years ago, wrote "Why does a magnificent applied science, which saves work and makes life easier, bring us so little happiness? The simple answer runs—because we have not

yet learned to make sensible use of it." If we can spend two billion dollars and the effort that went with this sum to perfect an improved instrument of destruction, we should—in fact we must—be willing to make equal or greater expenditure of time, talent, and money in making "sensible use" of our present knowledge.

* * *

Walter F. Loehwing, the author of our featured review, is a mid-westerner. Like many mid-westerners, he is friendly, enthusiastic in his activities, and likeable. Born in Chicago, he obtained his training in the Chicago public schools and the University of Chicago, receiving from this latter institution three academic degrees including his doctorate. Before he achieved his last degree, however, his training was interrupted by two important events: World War I in which he saw service in France as a field artilleryman and a period of three years (1920-23) when he served as professor of chemistry and dean of Oklahoma State School of Mines. These three years convinced him of the error of his way and he returned to Chicago where he completed his doctorate in 1925 under Professors William Crocker and Charles A. Shull in plant physiology. Dr. Loehwing then received an appointment as assistant professor of botany at the University of Iowa where he has remained and where, in 1940, he became the head of the department.

DR. W. H. LOEHWING

One of his former students writes: "I first knew Dr. Loehwing as an excellent teacher. His obviously thorough scholarship and enthusiasm for his subject, coupled with his understanding and patience, made him one of the finest teachers in all my experience. I had some opportunity to observe his painstaking, yet creative research methods; of course, his first-rate publications are a matter of general knowledge to anyone interested in the field."

The research activities in which Dr. Loehwing has achieved marked distinction have been concerned with the mineral nutrition of plants as related to their growth and development. Nearly fifty papers, some of considerable length, have described these studies as well as studies concerned with the physiology of sex and of sex differentiation in plants. Included among these papers are reports of Dr. Loeh-

wing's investigation of plant growth-promoting substances to which he has referred in his excellent review. This subject is one which has aroused popular interest and sometimes undue hope of marvelous results. Indeed, one hopeful soul, Dr. Loehwing reports, wrote for samples of the growth promoter to use on his bald scalp. Presumably the hopeful one had argued that, since both hair and plants are forms of herbage that grow from a hard surface, both should respond to the promoter. Doubtless many of us are getting to the stage where we hope that reasoning by analogy—in this case at least — will not prove futile.

Dr. Loehwing's numerous research activities have brought well-deserved professional recognition. He has been president of the American Society of Plant Physiologists; he was a delegate of the United States government to the Sixth International Botanical Congress at Amsterdam, Holland, in 1935; and he is editor of *Plant Physiology,* one of our leading botanical journals. In addition, he is a member of many other professional organizations. His three years as teacher of chemistry early in his career must still continue to exert an influence for we note that among these professional organizations he still maintains membership in the American Chemical Society. Also of interest is his membership in our sister organization, the Iowa Academy of Sciences in which he served as treasurer for four years.

In recent years, in addition to his professional activity in the field of botany, Dr. Loehwing has become engaged in some of the broader social obligations of the scientist, including activities in the field of science and botany teaching at all scholastic levels, various war-time activities with the National Research Council and other organizations, membership on numerous university committees, service as a past lieutenant governor of Kiwanis, and other kindred responses to the numerous demands of the present social order. In this connection the editor would especially call attention to Dr. Loehwing's recent and timely article in *Science* for November 24, 1944, "Rehabilitation and the College Curriculum in Biology." This article deserves careful reading and consideration for it calls attention to many of the problems and difficulties in the era which we are about to enter.

Such varied and extensive activities can only mean, despite the laws of thermodynamics, either that there does exist a boundless supply of available energy or that Dr. Loehwing has discovered the fountain of perpetual youth.

* * *

The editor is indebted to Dr. John Breukelman, president of the Academy, and to Dr. J. C. Frazier, former Academy secretary, for information concerning Dr. Loehwing upon which the above brief sketch is based. Through Dr. Frazier, we are also indebted to Dr. R. B. Wylie of the University of Iowa for additional information. Any errors, however, which may have been made should not be charged

against the editor's sources of knowledge, but against the editor himself.

* * *

Perennial wheat, a wheat that each season persistently makes its appearance after its original sowing! What a boon to the farmer and what changes in our economy it would produce if it were a reality! To Kansans especially it would be of utmost importance as wheat is the most valuable crop produced in the state. There is still a long distance to be travelled and years of careful and painstaking work ahead, however, if ever it is to become an actuality. Academy members should feel fortunate that through the efforts of Messrs. Reitz, Johnston, and Anderson we publish (page 151) in this issue a review of the literature and a report of Kansas experiments in this direction. Do not fail to read it.

* * *

The editor wishes to call particular attention to the news column in this issue. Although admittedly incomplete, it does give some idea of the many and varied scientific activities that have taken place in the state during the summer. In addition, glancing backward through the news columns of past quarterly issues, one secures directly, or by inference, a picture of the very real contribution which Kansas scientists have made to the war effort. The record on these pages, which again is far from complete, is nevertheless one of which we may all be proud. Please remember, too, that save for publication in the *Transactions*, much of this impressive achievement would have had no permanent record.

Scientific News and Notes of Academy Interest

Items for this column are solicited from all Academy members. For inclusion in any given issue they should be in the editor's hands at least three weeks before our publication dates, namely the fifteenth of March, June, September and December.

Dr. John H. Parker, director of the Kansas Wheat Improvement Association, Manhattan, resigned his position August 1 to become director of the Midwest Barley Improvement Association, Milwaukee, Wisconsin.

The resignation of Dr. Parker, a member of the Academy since 1918, is a real loss to Kansas. As the originator of Tenmarq, Pawnee, Comanche, Wichita and Quivira wheats, Dr. Parker has contributed greatly not only to the economy of Kansas but to the economy of the entire hard winter wheat region of the Great Plains.

In addition to his work as plant breeder, Dr. Parker, while a member of the staff of the Kansas State College, was a most successful teacher. His former students are occupying places of responsibility with the United States Department of Agriculture and many state experiment stations.

Dr. Parker will be succeeded by Mr. Clifford E. Skiver, since

1930 associated with the Agricultural Experiment Station at Purdue University.

The Agricultural Experiment Station reports that the new wheats, Comanche and Pawnee, in 1945 maintained their high record among varieties of wheat in Kansas. Comanche was selected at the Kansas Station from a cross of Oro x Tenmarq and Pawnee at the Nebraska Experiment Station from a cross of Kawvale x Tenmarq. Both varieties have been extensively tested since 1937 in Kansas and other states. These varieties are bearded, hard red winter wheats. Comanche appears best adapted to central, south central and southwestern Kansas. Pawnee is adapted especially to the hard wheat producing areas in central and eastern Kansas. The superior characteristics of Comanche are high yield, good test weight, earliness, stiff straw, milling and baking qualities equal to Tenmarq, high resistance to many important races of stinking smut and considerable resistance to leaf rust. Comanche is susceptible to loose smut and Hessian fly, shows tolerance to stem rust and is moderately winter hardy. The superior characteristics of Pawnee are high yield and test weight, short stiff straw, high resistance to loose smut and moderate resistance to leaf rust, stem rust, stinking smut and Hessian fly, and moderate winter hardiness. Pawnee has good milling qualities and has been satisfactory for bread baking.

In 1945 about 20,000 acres of each of the varieties were grown in Kansas from certified seed and a considerable acreage from uncertified seed. Most of this crop will be used for planting in the fall of 1945. The good yields made by these varieties account in large part for their rapid spread. Pawnee in experiments has yielded 8% higher than Comanche, which in turn has yielded from 5-30% higher than varieties commonly grown on farms. The percentage advantage of Pawnee over Red Chief has been 13; over Chiefkan, 14; Tenmarq, 19; Early Blackhull, 21; Blackhull, 28; and Turkey, 40. Further description of these two new wheat varieties will be found in Bulletin 319, *Comanche and Pawnee: New Varieties of Hard Red Winter Wheat for Kansas* by L. P. Rietz and H. H. Laude. The bulletin may be obtained by addressing the Agricultural Experiment Station, Manhattan.

Dr. H. V. Truman has been appointed professor of biology at Southwestern College, Winfield. Dr. Truman goes to Southwestern from Albion College, Michigan. He received his doctorate from the University of Wisconsin and has spent several summers as naturalist for the U. S. National Park Service in Yellowstone Park.

Among those returning this past summer from leaves of absence at Kansas State College, Manhattan were:

Professor O. D. Hunt, department of electrical engineering from Sylvania Electric Company.

Professor Wilson Tripp, department of mechanical engi-

neering from the Ryan Aircraft Company, San Diego, Calif.

Professor Florence McKinney of the department of household economics from Ohio State University.

Professor Abby Marlatt of the department of food economics from the University of California.

Correlation of Rocks of Simpson Age in North Central Kansas with the St. Peter Sandstone and Associated Rocks in Northwestern Missouri, by Constance Leatherock, geologist for the U. S. G. S., is the title of Bulletin 60 recently published in the State Geological Survey. The bulletin contains 16 pages, two figures and 1 plate. Copies may be secured for a mailing charge of 10 cents by addressing the State Geological Survey, Lawrence.

Dr. George A. Dean of Kansas State College, Manhattan, retires after forty-three years' service to the college and to the state. Dr. Dean, a former president of the Academy, now has the title of professor emeritus of entomology.

Professor Edward D. Kinney who has been serving half time during the past several years as metallurgical engineer for the North American bomber plant in Kansas City will resume his full time teaching duties this fall as associate professor of metallurgy at the University of Kansas.

Miss Ella Bernstorf returns to the faculty of Southwestern College, Winfield, as adjunct professor of mathematics after some years' service at State Teachers College, California, Pa. Miss Bernstorf succeeds Professor W. L. Shepherd who has been drafted into government service.

Dr. C. O. Swanson, professor of milling industry at Kansas State College, Manhattan, retires after service with the College beginning in 1906.

Dr. R. C. Moore, state geologist, was released from service in the U. S. Army early in the summer and has been collecting fossils in the Glass Mountains of Texas. He has been granted a leave of absence for the fall to do stratigraphic work in Texas and other areas of the Southwest for the U. S. Geological Survey.

Dr. Josephine Kremer has been appointed professor and head of the department of household economics at Kansas State College, Manhattan, succeeding Miss Ruth Lindquist who resigned during the summer. Dr. Kremer goes to Manhattan from New York University with prior experience at the University of California. She received her doctorate from Cornell in 1938.

Dr. E. Raymond Hall, director of the museum of natural history, University of Kansas, headed a party of seven that made an extensive collecting trip in Wyoming and Nebraska during the summer. Mammals were the principal objective and special attention was given to

rabbits along the eastern side of the Rocky Mountains because of their relation to spotted fever and tularemia. In addition to Dr. Hall and Dr. A. B. Leonard, the collecting group consisted of Mr. Bernardo Villa, Mr. Henry Setzer; Mr. James Honey and Dr. Hall's two sons, Hubert and Ben.

Dr. Roy A. Bowers, associate professor of pharmacy at the University of Kansas, has resigned his position to accept the deanship of the newly organized school of pharmacy at the University of New Mexico, Albuquerque.

In the past two issues we have devoted space in these columns to the research centers being developed in this area, a practice which we shall continue in the future. In this issue we call attention to the University of Kansas Research Foundation at Lawrence, incorporated May, 1943, as successor to the Engineering Experiment Station which, in turn, had been established by the Kansas Board of Regents, March 1908.

As a separate corporate entity, the Foundation is empowered to acquire patents, to borrow money, to buy and sell property, and otherwise engage in the normal activities of a corporation. It operates on a nonprofit basis, so that all net income may be devoted to further research. Publications will be issued from time to time, which will describe the various investigations which have been brought to completion.

Dr. Eugene A. Stephenson, professor of petroleum engineering, was appointed the first director of the Foundation and has successfully brought the Foundation to its present state. Because of ill health, he was forced to resign his office on July first and Dr. R. Q. Brewster, professor of chemistry at the University, was made acting director.

The Foundation has in its employ Mr. Morris Teplitz and Mr. Harry Rosenstein, whose work was briefly described in our last issue. On July first of the present year, Dr. Clarence Grothaus, formerly professor of chemistry at Bethany - Peniel College, Bethany, Oklahoma, was added to the staff to investigate the use of various materials as extenders or fillers for plastics.

Other projects which have been under way this past summer include: chlorination studies of isobutane by Mr. Frank Jirik and Mr. Robert Taft, Jr.; the synthesis and insect-repellant properties of lactones by Mr. Robert Russell; separation of alumina from Kansas clays by Mr. Kenneth Hoffman; the study of certain types of human infection by Mrs. Jean Elder; a consideration of freight rates as they affect certain Kansas products by Professor L. L. Waters; and studies of Kansas financial institutions by Professor L. J. Pritchard.

Dr. J. D. Stranathan, professor of physics at the University of Kansas, is engaged in preparing a 17,000 word article on "Radiation" for the new printing of *Encyclopedia Britannica.* Dr. Stranathan, well known for

his book *Particles of Modern Physics,* will review the various types of electro-magnetic waves including those of radio frequency, infra-red radiation, visible light, ultra-violet radiation, and gamma and X-rays.

Dr. Donald J. Ameel, secretary of the Academy, was promoted this summer from assistant professor to professor of zoology at Kansas State College, Manhattan, and made acting head of the department, succeeding Dr. James E. Ackert.

Dr. James E. Ackert, past president of the Academy, for over thirtv years a member of the staff of Kansas State College, Manhattan, and since 1931, dean of the graduate school, retired on July first and became dean emeritus. Dr. Ackert was succeeded as dean of the graduate school by Dr. Harold Howe of the department of economics and sociology.

Oil and Gas in Eastern Kansas by John M. Jewett and George E. Abernathy is the title of Bulletin 57 recently published by the State Geological Survey. Containing 244 pages, 21 figures, 4 plates, an extensive bibliography and an index, the bulletin is a valuable source of information not only on the subject indicated by the title but on the general geology of eastern Kansas as well. The bulletin should prove of value to oil operator, landowner, business man and general scientific reader. Copies may be secured for a mailing charge of 25 cents by addressing the State Geological Survey, University of Kansas, Lawrence.

Dean Margaret M. Justin of the school of home economics, Kansas State College, Manhattan, has been elected for a two-year term to the first vice-presidency of the American Association of University Women.

The Goodyear synthetic rubber plant at Topeka is nearing completion after delays caused by adverse weather conditions, war-time shortages and strikes. The plant at full capacity will require 1,075 employees to staff all operations, many of the employees being highly skilled workers. Included among these workers will be a small scientific staff of about ten; most of the strictly scientific work, however, will be carried on at the parent plant in Akron, Ohio.

Although the plant has been in operation for some time, its production up to the present has gone solely to supply military needs. Now that the war is over, conversion to civilian production will be quickly made and the plant will then be operated at capacity for the production of popular-size truck, farm and passenger tires and tubes.

This new chemurgic industry in Kansas will have a daily maximum output of 12 to 15 carloadings per day and a similar quantity of raw materials will be daily received.

Although little information is available on the chemistry of the process that will be employed in the Topeka plant, text-book information indicates that synthetic rubber from grains involves

(1) fermentation of grain to alcohol; (2) conversion of alcohol to butadiene; and (3) the polymerization of butadiene.

In this connection the following data of Jacobs on alcohol yields (*Ind.* and *Eng. Chem.* 31, 165 (1939)) is of interest in a starch producing state:

Raw Material	Alcohol gal./acre	Yield gal./ton
Potatoes, white	178.0	22.9
Potatoes, sweet	141.0	34.2
Corn	88.8	84.0
Grain sorghum	35.5	79.5
Wheat	33.0	85.0

From the standpoint of the manufacturer, wheat and corn appear to be the logical raw materials; a fact of considerable significance to Kansas. Recent work (1943) has shown that it is possible to secure yields of 2.5 gallons of alcohol per bushel of corn and 2.7 gallons per bushel of wheat.

Mr. R. B. Schwitzgebel has resigned his position with the U. S. Bureau of Entomology and Plant Quarantine, Hutchinson, to accept a position as entomologist with the Rohm and Haas Chemical Company, Bristol, Pa.

Mr. E. P. Sellner has been appointed to the newly-created position of assistant professor of sanitary science and office engineer for the State Board of Health at the University of Kansas. He is a graduate of the Case School of Applied Science and of Harvard University.

Profs. Ernest K. Chapin and Stuart E. Whitcomb of the department of physics, Kansas State College, Manhattan, will return to their teaching duties at Manhattan this fall. Mr. Chapin has been engaged in defense work at the Shure Acoustical Co., Chicago and Dr. Whitcomb at the Aberdeen Proving Ground, Maryland.

The extensive field activities of members of the State Geological Survey during the past summer include:

1. Cooperative ground water projects with the U. S. G. S. by B. F. Latta in Kingman County; C. C. Williams in Rice County; T. G. McLaughlin in Pawnee and Edwards Counties; J. C. Frye in Norton County.
2. Coal resources survey of the Wabaunsee group in eastern Kansas by W. H. Schoewe.
3. Collection of limestone samples for chemical analysis along the Kansas river valley by J. M. Jewett.
4. Collection of clay samples and shales for ceramic studies in central Kansas by Norman Plummer.
5. Field work on mineral deposits in southeastern Kansas by G. E. Abernathy.
6. Continuation of work on subsurface oil and gas producing rocks of Salina basin (in cooperation with the U. S. G. S.) by Wallace Lee, Constance Leatherock, and T. Botinelly.
7. Cooperative topographic mapping with the U. S. G. S. in Crawford, Bourbon, Neosho, Labette and Jefferson Counties under the direction of C. L. Sadler, division engineer.
8. Inventory of oil and gas producing areas and collection of well cuttings in east central Kansas by C. P. Kaiser.

Dr. E. G. Bayfield, professor

and head of the department of milling industry at Kansas State College, Manhattan, resigned during the summer to accept the directorship of products control and research for the Standard Milling Company, 309 West Jackson Boulevard, Chicago. Dr. Bayfield will be succeeded at Manhattan by Professor J. A. Shellenberger.

Dr. M. L. Thompson of the State Geological Survey and department of geology, University of Kansas, who in 1944 discovered rocks of pre-Desmoinesian Pennsylvanian age in Utah, Wyoming, Colorado and Kansas, spent several weeks during the summer in the Llano Uplift of central Texas, in the Ardmore Basis of southern Oklahoma, and in western Arkansas studying pre-Desmoinesian Pennsylvanian rocks and making collections of fusulinid foraminifers. Such fusulinids offer excellent clues in the classification of American pre-Desmoinesian rocks and a report on their occurrence in America is in preparation. Geologists from the Oklahoma Survey, the Texas Bureau of Economic Geology, and several oil companies also took part in the field work.

Among the promotions at Kansas State College, Manhattan announced during the summer were: Dr. M. C. Moggie, *education,* from associate professor to professor; Dr. M. J. Harbaugh, *zoology,* from associate professor to professor; Dr. J. C. Frazier, *botany,* assistant professor to associate professor; William H. Honstead, *chemical engineering,* from instructor to assistant professor and Dr. M. L. McDowell, *chemistry,* from instructor to assistant professor.

Promotions announced at the University of Kansas during the past summer include that of Mr. G. W. Bradshaw to a full professorship in civil engineering. The following assistant professors were advanced in rank to associate professors: Dr. T. T. Castonguay, *chemical engineering;* Dr. H. H. Sisler, *chemistry;* Dr. C. A. Vander Werf, *chemistry;* Dr. John Frye, *geology;* Mr. Paul Haney, *sanitary engineering;* Dr. A. B. Leonard, *zoology.* Mr. J. Sheldon Carey, *ceramics,* was advanced from an instructorship to assistant professor.

Dr. L. C. Heckert, head of the physical science department, Kansas State Teachers College, Pittsburg, who is on leave and acting as the chief chemist of the Jayhawk Ordnance Works, is supervising an experimental program designed to aid in the conversion of the facilities of the Ordnance Works to peace-time uses. The major part of the experimental work is being carried out in the laboratories of the College.

From Wichita High School East we have the following news notes of summer activities: Mr. J. W. E. Stogsdill, instructor of physics, taught physics in the summer session of Friends University; Mr. Clinton Kaufman, aeronautics instructor, secured his pilot's license as the result of his summer's work; and Miss

Anna Belle Costin has been appointed instructor in physiology.

According to figures released by Dr. J. C. Frye, acting director of the State Geological Survey, mineral production in Kansas increased by nearly 80% from 1939 to 1943, although the percentage increase in the United States as a whole for the same period was 64%. These mineral statistics are compiled cooperatively by the State Geological Survey and the United States Bureau of Mines. The Kansas increase was, of course, due primarily to war conditions. Minerals that have had the greatest increase in production are the fuels: oil, gas, and coal. Zinc and salt also have had large increases in production but cement, which had a rapid increase during the war plant construction period, has again declined. The value of some twelve of these products in the five-year period 1939-1943 is tabulated below.

	Value in Millions of Dollars					
	1939	1940	1941	1942	1943	Total
Cement	5.6	5.2	7.1	11.4	8.0	37.3
Clay	1.1	1.0	1.1	0.9	0.7	4.8
Coal	5.1	6.7	8.0	9.3	11.4	40.5
Lead	1.3	1.2	1.7	1.3	1.4	6.9
Natural Gas	29.4	31.9	36.6	38.4	46.6	182.9
Natural Gasoline	2.0	1.3	2.6	2.4	3.3	11.6
Petroleum	63.1	68.7	95.7	117.1	127.4	472.0
Pumice	0.1	0.1	0.1	0.1	0.2	0.6
Salt	2.6	2.7	3.3	3.8	4.2	16.6
Sand and Gravel	0.8	0.9	1.3	2.8	2.1	7.9
Stone	4.6	3.7	3.2	3.0	2.3	16.8
Zinc	7.2	7.2	10.7	10.4	12.3	47.8
Total	122.9	130.6	171.4	200.9	219.9	845.7

Note that the value of these mineral products is expressed in millions of dollars. The five-year total, $845,700,000 (nearly a billion dollars) is an impressive figure and shows, if any other confirmation were necessary, that Kansas is no longer solely an agricultural state. The total value of wheat (in the production of which we lead the nation) and of corn produced in Kansas in 1942, for example, was $291,000,000, as against $201,000,000 for mineral production.

Dr. O. A. Hankhammer of Kansas State Teachers College, Pittsburg, has been made head of the department of industrial and vocational education, succeeding Dr. W. T. Bawden who has reached the administrative retirement age. Dr. Bawden will continue his teaching duties.

Dr. H. E. Myers, professor of soils at Kansas State College, Manhattan, has returned to Kansas State after a leave of absence beginning in August, 1943. Dr. Myers served as agriculture advisor to the U. S. State Department in the Middle East and was a member of a joint Anglo-American civilian supply agency. The agency was charged with the encouragement of local production of food to reduce necessary shipping space to the Middle East and to approve the importation of farm machinery and supplies.

Kernel Characteristics of Kansas Winter Wheat Varieties by Professor L. P. Reitz of Kansas State College, Manhattan, is the

title of a bulletin released this summer by the Agricultural Experiment Station. The bulletin describes methods of identifying eleven varieties of winter wheats including those types most extensively grown in the state and the two new varieties, Pawnee and Comanche.

The bulletin, containing 25 illustrations, should be of especial use to millers, farmers and teachers. Copies may be secured without charge by addressing the Agricultural Experiment Station, Manhattan, Kansas.

Dr. E. C. Miller, professor of plant physiology at Kansas State College, Manhattan, retired August 31 after 35 years of service and was given the title of professor emeritus. A dinner in his honor was given by Professor L. E. Melchers, chairman of the department, before Dr. Miller left Manhattan for Ohio, where Dr. Miller will again live in his boyhood home. Dr. Miller will be succeeded by Dr. J. C. Frazier, former secretary of the Academy.

Additions to the staff of the psychology department of the Menninger Clinic, Topeka, include Miss Elaine Grimm and Mrs. Sibylle Escalona. Internships in psychology for Mr. Martin Mayman and Mrs. Sarah Palyeff have been renewed for the coming year. Dr. David Rapaport, Mr. Roy Schafer, Dr. Margaret Brenman and Dr. Merton M. Gill have all been active during the year in presenting the results of numerous studies. In our next issue we hope to present a brief description of the Menninger Clinic and its activities.

Dr. Frank E. Hoecker, a graduate of the College of Emporia and of the University of Kansas, has been appointed associate professor of physics at the University. Dr. Hoecker taught for five years at the University of Kansas City but more recently has been senior physicist with the United States Public Health Service and is a specialist in radiology and in the application of X-rays and radio-activity in medicine.

Professor Margaret D. Bair, who has been on leave of absence the past year, has returned to Friends University, Wichita, to resume her position as head of the department of home economics.

Dr. Walter S. Long, professor of chemistry at Kansas Wesleyan University, Salina, reports that during the summer he carried out investigations on the chemical treatment of wood but the work from which he obtained the most personal satisfaction was the digging of a ditch 75 feet long, 3½ feet deep and 14 inches wide in 23 hours and for $23.00—and with no bad physical effects. The editor would give a good deal to be able to equal Dr. Long. In his younger days, the editor was a member of a ditch digging crew for a summer but his efforts were worth only two dollars a *day* for the back-breaking labor.

Dr. Fletcher McCord, assistant professor of psychology at

the University of Kansas, has resigned his position to accept an associate professorship in psychology at the University of Tulsa, Tulsa, Oklahoma.

Dr. Penrose S. Albright, head of the physics department of the University of Wichita was recently appointed assistant to the chairman of the board of governors of the University of Wichita Foundation for Industrial Research. He was instructed to direct a survey and to collect information on the industries of the Wichita area so that a director, when elected, will be able to assemble at once a staff of scientific personnel which can meet the needs of the area. Dr. Albright was lent by the University of Wichita to the University of Wichita Foundation for an indefinite period.

Dr. F. C. Gates of Manhattan, Dr. H. B. Hungerford of Lawrence, and Dr. Otto Trietel of Nashville, Tennessee, all Academy members, spent the summer in study and research at the University of Michigan Biological Station, Cheboygan, Michigan.

Dr. Robert Kammerer has been appointed assistant director of the Kansas Receiving Home for Children, Atchison. Dr. Bert Nash, director of the Home, will retain his post in a supervisory capacity but will return to the University of Kansas this fall to resume his duties as professor of education.

Mr. J. C. Mohler, secretary of the state board of agriculture, reports that the book *Birds of Kansas* by Dr. Arthur L. Goodrich of Manhattan is now in press. Mr. Mohler expects the book will be ready for distribution by fall or early winter.

Miss Eva McMillan, associate professor of food economics and nutrition at Kansas State College, Manhattan, has been granted leave of absence for the coming year. Professor McMillan will spend the year in travel and study in South America.

Changes in the staff of the Midwest Research Institute, Kansas City, have recently been announced. Dr. George E. Ziegler, physicist on the staff, has been appointed executive scientist in charge of all project production. Others appointed to head various departments of the Institute are Dr. George W. Ward, geologist and mineralogist, chairman of inorganic chemistry; Dr. C. L. Shrewsbury, chairman of agricultural research; Dr. Frank H. Trimble, physicist, chairman of applied physics research.

Recent additions to the Midwest staff, which now totals 47 persons, include the following: Dr. Carl M. Marberg of the Interchemical Corporation, New York, and Dr. Philip E. Pratt of the Bakelite Corporation, Bloomfield, N. J., as organic chemists; Lieut. Kenneth W. Moore, formerly chief of the photographic section of the Armour Research Foundation, Chicago, will be in charge of the same department at Midwest. For the past one and one-half years Lieut. Moore was staff in-

telligence officer of the 5th Air Corps, participating in eight amphibious landings in New Guinea, the Philippines and Celebes. He is a graduate of the University of Indiana, Bloomington; Armour D. Berneking, chemist, formerly with the Phillips Petroleum Company and Kansas City Power & Light Company, Kansas City, Missouri; Miss Helen L. Kilmer, assistant chemist, formerly with Pratt and Whitney and Bar-Rusto Plating Corporation, Kansas City, Missouri; Miss Marie F. Heider, assistant chemist, formerly with the Phillips Petroleum Company and Larabee Flour Mills, Kansas City, Missouri; Clifton R. Blincoe, assistant chemist, formerly of Missouri University; Miss Marian E. Shields, assistant chemist, formerly with Pratt and Whitney and Sewell Paint & Varnish Company, Kansas City, Missouri; Miss Phyllis Evans, assistant chemist, a student at Kansas State College; Miss Helen L. Muser, chemist, formerly with the Southwestern Laboratories, Kansas City, Missouri; Miss Lillian Leach, chemist, a student at University of Texas, Austin; Miss Mary Ellen Nichols, chemist, graduate of Transylvania College, Lexington, Kentucky.

Dr. S. M. Pady, associate editor of these *Transactions* and since 1937 professor of biology at Ottawa University, has resigned his position to accept an assistant professorship in the department of botany, Kansas State College, Manhattan.

Dr. Claude W. Hibbard, president-elect of the Academy, and curator of vertebrate paleontology at the University of Kansas museum, headed a party consisting of Mr. Russell Camp, newly appointed preparator in vertebrate paleontology at the University and Mr. Richard Rinker of Hamilton, which spent the summer in the field with headquarters at the Meade County state lake. During July the party worked the Cragin Quarry on the Big Springs ranch and along the canyons of the Cimarron river, making reconaissance for vertebrate fossil remains that were washed out during the year. A fossil quarry was established along the breaks of the Cimmaron late in the summer, the original party then being joined by Mr. Manuel Maldonado-Koerdell, Mr. Elmer S. Riggs and Dr. W. J. Baumgartner, managing editor of the *Transactions.*

Dr. R. E. Mohler of McPherson College and Mr. C. H. Dresher of McPherson High School were guests of the party for several days late in July.

Dr. Roger C. Smith of Manhattan and Mr. R. G. Yapp, assistant state entomologist, were sent to Iowa during the summer by the state board of agriculture to study the western progress of the corn borer. Observations were made on the type of injury done by the first generation European corn borer larvae to varieties of field and sweet corn so that more effective measures could be taken in Kansas surveys of this insect pest. The field demonstration attended by

Messrs. Smith and Yapp was held near Cedar Rapids, Iowa, with representatives present from Minnesota, North and South Dakota, Iowa and Kansas.

Professor Ray Rankin, head of the chemistry department, Fort Hays State College, has spent the summer making studies of municipal water softeners. He expects to make a report of the result of his investigations this fall.

Dr. Harvey Zinszer, department of physics, Fort Hays Kansas State College, who has been on leave in the Cruft Laboratory of Harvard University during the past year, has returned to the campus and will again take up his teaching as head of the department of physics in September. He has been assisting with laboratory work at Harvard in the pre-radar school for army and navy.

During the past summer, the U. S. Coast and Geodetic Survey established a triangulation station at Hiawatha, Kansas. For this purpose a seventy-seven foot double steel portable tower was temporarily erected on the grounds of the Brown County court house. The inner tower supported the theodolite centered over the monumented station on the ground and was entirely free from the outer tower, which was used to support the observing party and signal light. According to Rear Admiral Jean H. Hawley, acting director of the Survey, station HIAWATHA was established as a supplementary station to the main arc of first-order triangulation extending along latitude 40° from near Savannah, Missouri to near Humboldt, Nebraska, which was completed during July of this year. This is part of the network of triangulation which covers the entire United States based upon the North American Datum adopted in 1927. Triangulation involves the precise determination of geographic positions, distances and directions or azimuths computed and based on the geoid. Geographic positions, fixed in latitude and longitude, are of inestimable value as control points for all local mapping, property surveys, or other engineering activities. Fourteen hundred of such points have been established in Kansas. Even though a monumented position be lost, it can always be precisely redetermined. Additional control points may be established by traverse from any one station or by triangulation from any two. The triangulation points are precise reference points for the exact locations of state and county boundaries and of farms and still smaller parcels of land, and for the basic control of all local surveys, or engineering or scientific operations which require precise geographic position. This particular arc of triangulation will furnish basic geographic control to the U. S. Army Corps of Engineers in their plan for the development of the Missouri River Valley.

Our membership campaign is making progress and with the advent of fall we should return with enthusiasm to our goal for the year—the doubling of the

Academy membership. Since the annual meeting in April some 102 members have been added to our roll. The University of Kansas is slowly reaching toward its objective of a tripled membership, but the largest percentage increase to date has come from William Jewell College in *Missouri.* Through the efforts of Dr. L. J. Gier, William Jewell has undergone a 500% increase in membership, certainly a mark for us all to shoot at. Fort Hays Kansas State College hopes to have its membership doubled shortly and other schools are making active efforts in the same direction. Our library subscription list, too, has doubled in recent months.

A new era is upon us. Even the lesson of victory itself brings with it profound concern, both for our future security and the survival of civilization. The destructiveness of the war potential, through progressive advances in scientific discovery, has in fact now reached a point which revises the traditional concept of war.

Men since the beginning of time have sought peace. Various methods through the ages have attempted to devvise an international process to prevent or settle disputes between nations. From the very start, workable methods were found, in so far as individual citizens were concerned, but the mechanics of an instrumentality of larger international scope have never been successful. Military alliance, balances of power, leagues of nations, all in turn failed, leaving the only path to be by way of the crucible of war. The utter destructiveness of war now blots out this alternative.

We have had our last chance. If we do not now devise some greater and more equitable system, Armageddon will be at our door. The problem basically is theological and involves a spiritual recrudescence and improvement of human character that will synchronize with our almost matchless advance in science, art, literature and all material and cultural developments of the last 2,000 years. It must be of the spirit if we are to save the flesh.—General Douglas MacArthur, September 2, 1945.

New Combinations of Genes in Wheat x Wheatgrass Hybrids *

L. P. REITZ, C. O. JOHNSTON, and K. L. ANDERSON†

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Crossbreeding of wheat (*Triticum*) and wheatgrass (*Agropyron*) has been a subject of interest among plant breeders for more than a quarter of a century. The much publicized objective has been the development of a perennial wheat; however, of equal or greater importance is the development of new gene combinations in strains of wheat or of wheatgrass which would render the present species of greater economic worth.

Hillman [4] gave an account of a hybrid made in 1903 between wheat and *Agropyron*. It is improbable that a cross was achieved in this instance and, as Percival cautioned [7], "further evidence is necessary before the hybridization of these plants can be accepted." However, successful hybrids were obtained in the U.S.S.R. in 1930 by N. B. Zizine, often transliterated as Tzitzin [9]. Breeders in Canada and the United States made their first fertile hybrids in 1935 [1, 10]. Workers at several experiment stations have since shown that crosses of the wheat and wheatgrass genera are possible.

Species of wheatgrass are perennial. Single plants live for several years and one seeding will persist in much the same manner as alfalfa or bluegrass. Gates [3] reported six species of *Agropyron* in Kansas but of these only one, *Agropyron smithii* or western wheatgrass, was widespread in the state and well adapted while *Agropyron trachycaulum* or slender wheatgrass occurred in slight amounts. Hybrids of these two species with wheat were attempted by Johnson [5] and Smith [8] but no seeds were obtained. The species which have been successfully hybridized with wheat are not native to Kansas and do not thrive in this area. All species of wheat are annual or winter annual in growth habit. By hybridizing these genera new types of grasses might be evolved. The possibilities are: 1. a long-lived wheat-like plant that would yield a harvest of grain in consecutive years from one sowing; 2. a dual-purpose type yielding

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†Associate Agronomist, Pathologist, and Associate Agronomist, respectively.

some grain and suitable forage; and 3. a forage type might be developed with seeds larger than those of the common grasses. Furthermore, resistance to diseases, insects, drouth, winterkilling and other hazards might be introduced into the annual wheat and make it a more dependable crop for grain or pasture. Species of *Agropyron* furnish a valuable new source of such characters. Thus the possibilities in these hybrids have lured plant breeders. Now, after more than a decade of work in the United States and Canada and 15 years in Russia it has been established that crosses can be made which will produce seed, that a large variety of types can be secured from which selections may be made, and that wheat and wheatgrass characters can be combined in variable amounts.

Thus far, no varieties of commercial value have come from these crosses, save for the possibility of such in Russia. There appear to be several reasons for this: 1. crosses of these genera are difficult to make and the number of crossed seeds has been relatively small; 2. sterility is high in the hybrids requiring backcrossing to the parents or chromosome doubling in the hybrids to maintain the lines in many cases; 3. a period of 10 to 15 years is too short for practical results, considering the relative dissimilarity and apparent incompatibility of the parental forms.

Review of Literature

In a recent paper, Smith [8] cited 25 scientific reports of results from crosses of wheat and *Agropyron*. These citations were carefully chosen and represent the most valuable and authentic reports of crossing work up to the year 1942. In addition to reports on crossing cited by Smith, Johnson [5] and Armstrong and McLennan [2] cited 11 other reports which contained results of chromosome studies, degree of fertility in the hybrids, genetic recombinations in segregating generations, results of backcrossing, and reports on longevity, agronomic characteristics and seed quality of the hybrid progeny. Over 20 other useful scientific papers have appeared.

Numerous articles have appeared from time to time in popular magazines, and in daily and weekly newspapers. Fact and fancy usually have been inextricably commingled. Beyond comparison, for a practical fair statement, was that by McCall [6]. He gave the basis for hope of success but clearly enumerated the difficulties to be overcome before a perennial wheat would be a practical crop in the great wheat belt of North America. He emphasized that ecologi-

cal factors such as moisture and nutrients would be important limiting elements.

A review of the literature shows that two species of *Agropyron* have been successfully hybridized with 28- and 42- chromosome wheats in Russia, Canada, and the United States, namely *Agropyron glaucum* or *intermedium* and *A. elongatum*. These and other species used successfully are listed in Table 1. A large number of crosses involving other species have been attempted either with no effects, or effects ranging from slight ovary stimulation, and formation of germless seeds, to apparently normal seed producing defective seedlings. Varieties of wheat and of wheatgrass often exhibit differential degrees of crossability, hence the use of other varieties might bring success. The difficulties of work of this nature are great and the progress slow. This is well illustrated by the fact that W. J. Sando began making wheat × *Agropyron* crosses at the Arlington Experiment Farm in 1923 but not until 1935, after using several species of *Agropyron*, and various varieties of wheat, were fertile crosses obtained.

Experiments in Kansas

Hybrids involving *Agropyron elongatum, A. glaucum* and *A. tricophorum* crossed with wheat have been given limited tests in Kansas. Several types are illustrated in Figures 1, 2 and 3. Strains tested have been selections from crosses made in Canada or by workers in the United States Department of Agriculture. Attempts to get seed of the strains developed in Russia have not been successful. E. R. Sears, U.S.D.A., Columbia, Missouri, in 1944 sent F_1 seeds from five crosses originating at the Siberian Agricultural Institute, Omsk, U.S.S.R., but only one seed germinated. It came from the cross *Triticum dicoccum farrum* × *Agropyron glaucum*. This plant grew rapidly, headed promptly like a spring wheat and bore several awnless spikes that were fully self-fertile. Later tests must be given this strain to establish its worth.

Two annual strains of *Triticum* × *Agropyron elongatum* backcrossed to wheat, originally obtained from W. J. Sando, U.S.D.A., have been grown in the agronomy nursery at Manhattan for several years. They are largely self-fertile but do not persist into the second year. Descriptions and experimental results are given in Table 2. It is apparent that distinct types may be selected, some of which may have desirable characters such as disease resistance. Neither strain has given as much seed or forage per unit of area as the Turkey

wheat check grown nearby although strain 637 has appeared very much like common wheat in plant characters and survived each winter with good stands.

FIG. 1. Typical plants from wheat X wheatgrass crosses. From left to right: wheat X A. elongatum S4-207 X wheat, C.I. 12348, C.I. 12351, Mindum X A. trichophorum X wheat, and strain 637. (See text).

Thirty-three other plants from W. J. Sando's crosses involving wheat $\times$ *Agropyron elongatum* backcrossed one or two times to wheat were tested for rust in the greenhouse in 1941. Of these, eight gave zero readings to leaf rust and all were resistant to stem rust. The plants were transplanted to the field but none behaved as perennials in this climate. Another group of plants was received in 1944 representing new selections from similar crosses but having more perennial-like tendencies. In the greenhouse they showed

variation for mildew and aphid resistance but have not been tested for rust.

TABLE I

Species of Wheatgrass Successfully Hybridized With 28- and 42-Chromosome Wheats

Species	Chromosome Number (2n)	Success Achieved In— Russia	Canada	United States
Agropyron glaucum (intermedium)	42	Yes	Yes	Yes
Agropyron elongatum	56	Yes	......	......
Agropyron elongatum	70	Yes	Yes	Yes
Agropyron trichophorum	42	Yes	......	Yes
Agropyron junceum	28	Yes	No*	......
Agropyron repens	42	Yes	No	No
Agropyron amurense	......	......	......	Yes

*One seed obtained in crosses with *Triticum persicum*.

TABLE II

Data on Annual Types of *Triticum-Agropyron* Hybrids Grown in the Plant Breeding Nursery at Manhattan, Kansas. 1942-1944.

Strain Type	1942 Data Leaf rust %	1942 Data Grain yield grams	1943 data Date Headed	1943 data Leaf rust %	1943 data Ht. In.	1943 data Grain yield grams*	1944 data Date Headed	1944 data Stem rust %	1944 data Leaf rust %	1944 data Ht. In.	1944 data Grain yield grams*
637 Wheat-like, seed free	10	17	5-25	40	39	102	5-27	T-40	T-20	41	63
881 Grass-like, seed covered	0	6	6-2	T	27	6	6-1	0	T	30	12
Turkey ck. wheat	50	36	5-27	60	40	126	5-29	40	60	44	90

*Grain from 8 square feet.

Seeds from open-pollinated Mindum durum × *Agropyron trichophorum* F_1 plants of perennial habit were obtained in 1943 from C. A. Suneson, United States Department of Agriculture, Davis, California. From these, 31 plants were grown in the greenhouse during 1943-44. Nine of the plants were small tufted, glossy-green, grass-like types and perhaps perennial in nature since they failed to head at the normal time. Sixteen plants had tall weak straw with blue-green leaves and annual habit of growth. The remaining six appeared to be intermediate in plant type and habit of growth. All plants that headed had extremely weak straw and long, lax, awnless heads with pubescent glumes like the *Agropyron* parent. The plants were highly self-sterile, only seven producing any seed. In all, 82 kernels were obtained, 50 of which resulted from backcrossing with wheat pollen. From these, 45 plants were grown in the greenhouse in 1944-45. Only nine appeared to be of the small, tufted, grass-like, perennial type; all others seemed to be annual or intermediate in habit. However, perennial character often is not clearly evident in plants grown in pots in the greenhouse.

The backcrosses varied widely in head characters of which some were awnless, some partially awned, and some completely awned. Some had heavy pubescence on the glumes while others had

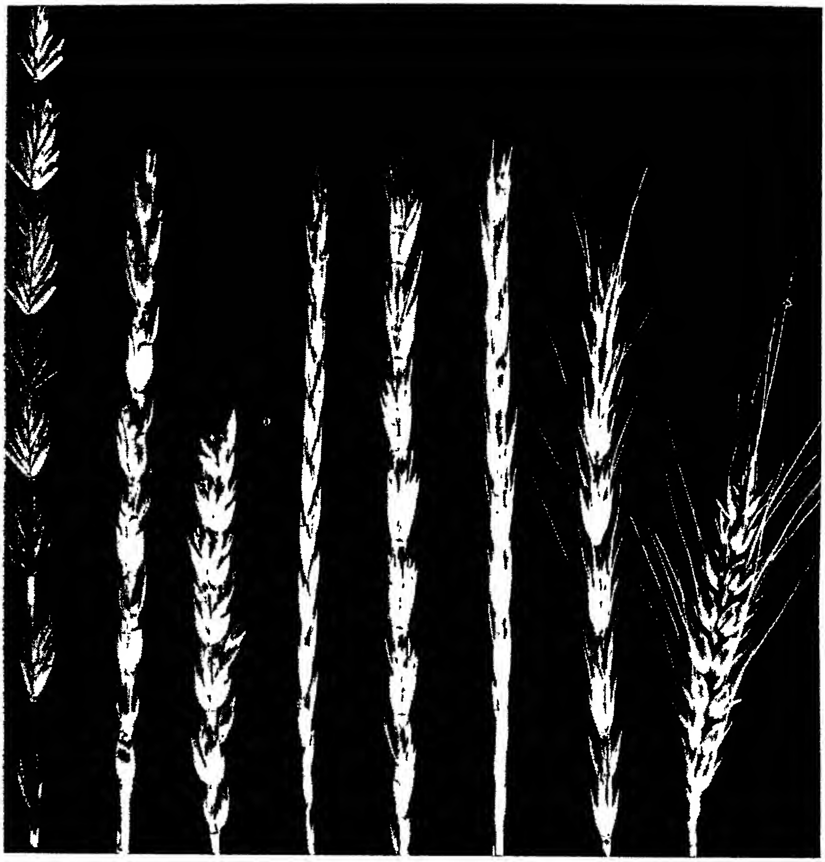

FIG. 2. Spike types of wheat and wheat X wheatgrass hybrids. Agropyron elongatum (left), common wheat (right) and hybrid types.

glabrous or scabrous glumes. Most of the plants had long, lax, grass-like spikes with widely spaced spikelets but a few had broader, denser, more wheat-like heads. The backcrosses proved to be nearly immune to leaf rust of wheat (physiologic race 9) except for eight plants which showed considerable resistance. In 37 plants flecking was the only sign of infection. When the plants were inoculated with stem rust (physiologic race 56) 10 plants were nearly immune, 18 were highly resistant, 10 were moderately resistant, 4 were susceptible, and 3 plants escaped infection. It appears, therefore, that a high degree of resistance to leaf and stem rusts can be transmitted to wheat × *Agropyron* hybrids. Most of the plants again were nearly self-sterile and backcrossing with wheat pollen was used to

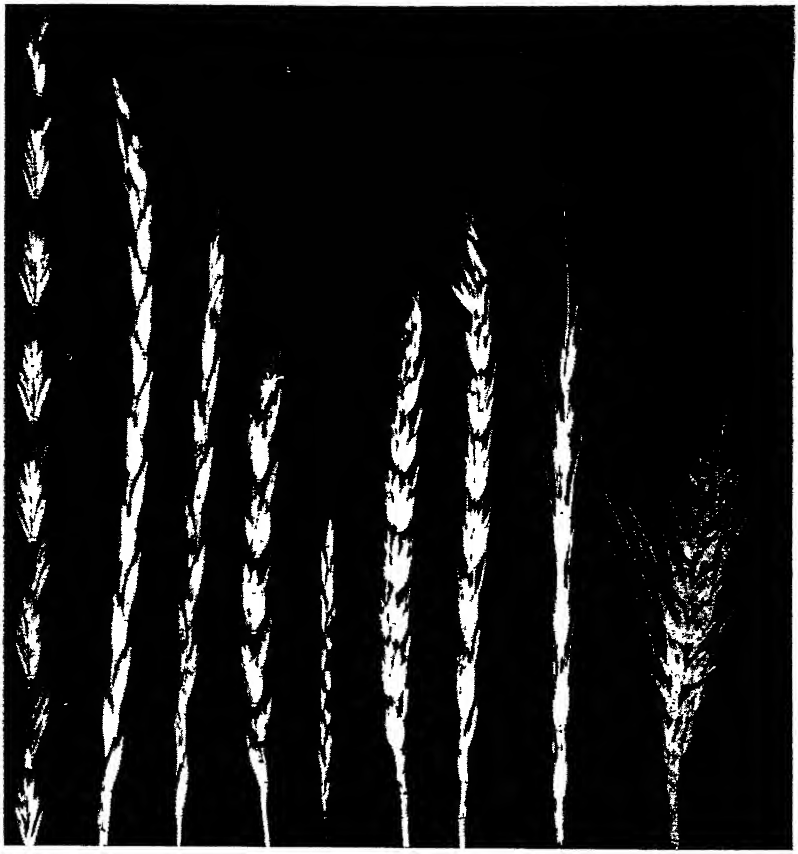

FIG. 3. Spike types of A. trichophorum (left), common wheat (right) and hybrids.

produce some grain. Such kernels usually were very large, greatly distending the glumes.

Two strains of simple *Triticum* × *Agropyron elongatum* crosses in F_3 were obtained from the Central Experiment Farm, Ottawa, Canada. The plants persisted for two years in the nursery at Manhattan before being plowed up. Seed set was sparse, the seeds were not free threshing and the vegetation was harsh in character similar to the wheatgrass parent. Very little leaf and stem rust developed on these plants while susceptible common wheat grown nearby died prematurely from excessive rust infection. Greenhouse tests in 1941 on 22 of these plants indicated high resistance to stem rust and the

zero type of reaction to leaf rust (physiologic race 9) although flecks occurred rather prominently in several plants.

Another group of wheat × *Agropyron* crosses studied consisted of three amphidiploid lines C.I. 12348, C.I. 12349, and C.I. 12351 and S4-207 received from T. M. Stevenson, Ottawa, Canada. The complete designation on the strains with C.I. numbers was as follows: Vernal emmer × *Agropyron glaucum* Canadian No. S91 F_5, C.I. 12348; *Triticum turgidum* (49) × *Agropyron glaucum* (1087), Canadian No. S107 F_4, C.I. 12349; Kharkof × *Agropyron glaucum,* Canadian No. S147 F_3, C.I. 12351. In the greenhouse all of these produced robust plants with long, broad, rough, blue-green leaves. The straw was very tall and weak and the heads were long, lax and grass-like with very short awns. In the greenhouse the plants were partly sterile. These strains were tested with leaf rust physiologic races 5, 9, 15, 44, and 126. All were nearly immune from all races except C.I. 12348 in which a few plants were only moderately resistant to race 15. The selection S4-207 was backcrossed with common winter wheat in 1944 and 9 kernels were obtained. Plants from these were grown in the greenhouse in 1945. All of them proved to be nearly immune from leaf rust physiologic race 9. Two plants were nearly immune from stem rust race 56 while the remaining 7 plants were highly resistant.

A final small group of wheat × *Agropyron* studied consisted of two lines of wheat × *Agropyron elongatum* received from C. A. Suneson, Davis, California, from crosses originally made by W. J. Sando. Only one plant of each line produced seed in the greenhouse in 1944. Both plants appeared to be annual in habit and both had awnless wheat-like heads. One line had persistent glumes and large wheat-like blue kernels. The other appeared to thresh easily and produced large wheat-like hard red kernels. The former plant produced 16 kernels and the latter 13 kernels from which 14 and 8 plants, respectively, were grown in the greenhouse in 1945. All of the plants of both lines were nearly immune when inoculated with leaf rust (physiologic race 9). Only 7 plants were nearly immune from stem rust (physiologic race 56) but 8 additional plants were highly resistant and 7 were moderately resistant.

Discussion and Conclusions

All of the experiments in Kansas must be considered preliminary and the results indicative, not conclusive. Tentative plans have been made to enlarge the scope of experiments on perennial wheat

in Kansas when conditions permit. Seed from research workers in the United States and Canada is being assembled and efforts will be continued to get seed from Russia. At present, 129 different strains have been accessioned and placed in storage, while only a few are being tested in nursery and greenhouse plantings. New crosses, further back-crossing both to *Triticum* and to *Agropyron,* and re-selections of strains already available are contemplated. These, when tested and studied adequately, should yield information upon which sound conclusions can be based.

These studies indicate that grass-like perennial types are more readily selected than perennial wheat-like forms, larger seed size on grass types may be achieved, and potential disease resistance of a high order may be transferred to 28- and 42- chromosome wheats. The economic aspects of this work and the promise in such hybrids is unknown although none of the strains tested seems to have immediate practical value for this area.

More than a decade of work in the United States and Canada and 15 years in Russia have shown that the wheat and wheatgrass genera can be hybridized and that parental characters can be combined in variable amounts in the progeny from such crosses.

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Testing for Leadership in Industry

IRVIN T. SHULTZ* and BENTLEY BARNABAS†

Introduction

The problem of selecting personnel for industry on the home front is second only to the efficient utilization of human resources in the armed forces. Psychological techniques are making signficant contributions to both aspects of this problem. Beginning in December, 1943, The Coleman Lamp and Stove Company, of Wichita, Kansas, commissioned the firm of Search-Service, Inc., (with which the authors were then actively connected) to conduct research to determine the value of aptitude tests as an aid in the selection of factory leaders for upgrading and for future replacements.

Description of the Criterion Sample

To provide the Coleman Company with a standard for the selection of leaders, it was decided after some preliminary testing to use a sample of 30 foremen and assistant foremen drawn from all departments of the factory. Although this was a comparatively small group, these 30 men constituted 88 per cent of the men at this job level. The average age of the group was 43; the youngest was 30, the oldest 60. The group was slightly skewed toward the younger level.

The average Coleman leader had been with the firm for 18 years; one man had been with the firm 32 years; the shortest length of service was 6 years.

On the average the education of these leaders in the Coleman plant could be compared to that of a high school student who had completed his second year in high school. One was a college graduate, one got no further than the fourth grade. All were white native-born Americans.

How the Criterion Was Determined

It was first thought that the criterion against which the tests were to be validated should be a composite rating of age, education, experience, "budget control efficiency" and "employee relations." Later preliminary experiments established that a composite rating of the

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30 leaders on two measures—"budget control efficiency" and "employee relations"—was the most valid. These two ratings became the criterion, referred to as "Ratings" in this study. They were obtained in the following manner: On the basis of objective evidence which was available, the factory manager was asked to rate each man on his ability to control production costs. This constituted his "budget control efficiency" rating. They were then divided roughly into five groups and re-rated within the five groups, the lowest being given a score value of one, the highest, fifteen. Care was taken that no "halo" effect or other avoidable conditions would affect the score.

The personnel director was asked to determine an "employee relations" rating for each of the thirty men on the basis of his ability to get along with the employees under his direction. This rating was the composite of incidents which showed job satisfaction on the part of the individuals supervised by the foremen and assistant foremen. "Do the men like, respect, and follow this leader?" was the question which the personnel director was answering. The same procedure of classifying was adopted in this case as in the budget efficiency ratings.

These ratings were made in September, 1944. Five months later in February, 1945, they were repeated. The budget control efficiency ratings made by the factory manager correlated 0.95 with his previous rating. The personnel director's ratings on Employee Relations correlated 0.66 with his earlier ratings.

The correlation between the first budget control efficiency ratings and the first employee relations ratings was 0.21. The correlation between the two, five months later, was 0.38. The correlation between the combined September ratings and the combined February ratings was 0.85.

It is obvious that the two parts of the criterion would be expected to show a low relationship. A foreman who is careful about budget control might not be sensitive to employee relationships, and vice versa. However, after some discussion it was decided that an average of the four ratings would be used as the composite criterion score for each man, and these were computed and the men re-ranked in terms of this composite criterion.

The Testing Program

The next problem was to find a battery of tests which would show a relatively high relationship with the criterion, and low intercorrelations among themselves. Under carefully controlled con-

ditions and in the same manner the following tests were administered to the thirty foremen and assistant foremen: The *Bernreuter Personality Inventory,* published by Stanford University Press; the *Otis Quick-Scoring Mental Ability Test,* published by the World Book Company, Yonkers-on-the-Hudson; the *Bennett Test of Mechanical Comprehension,* Form A, published by Psychological Corporation, New York City; and the *Strong Vocational Interest Blank for Men,* published by Stanford University Press.

Treatment of Data

Since the criterion ratings and the raw scores on the standardized tests were all normally distributed, it was possible to reduce all distributions to a comparable basis by converting raw scores into standard or T-scores through the application of the following formula:

$$\text{T-score} = \frac{10\ (\text{Raw Score} - \text{Mean of Raw Scores})}{\text{Standard Deviation of the Distribution}} + 50$$

The T-scores then became the basis for the calculation. The coefficients of correlation are shown in Table I and are Pearson Product-Moment *r's.*

An inspection of Table I reveals that while all correlations show a low relationship with the criterion (the composite of budget control efficiency and employee relations marked simply "Rating" on the table), these correlations are not without predictive value in industry.* The *Otis Intelligence Test* was dropped because of its low correlation with the criterion, —.02.

The two scales from the *Strong Vocational Interest Test,* "Production Manager Interest" and "Occupational Level of Interests," were selected together with the *Bernreuter Personality Test* and the *Bennett Mechanical Comprehension Test* as the best combination which would produce the highest relationship with the ratings, the criterion.

Table I

Intercorrelations between the Criterion Rating and the five variables. Lower left are correlations corrected for attenuation.

	Rating	Prod. Mgr.	Occ. Lev.	Personality	Otis MA	Mech. Comp.
Rating (Criterion)		0.38	0.22	0.36	—0.02	0.11
Production Manager	0.44		—0.13	0.19	0.09	0.27
Occupational Level	0.26	—0.15		—0.07	0.27	0.26
Personality	0.42	0.22	—0.08		—0.11	—0.23
Otis Mental Ability	—0.02	0.10	0.30	—0.12		0.47
Mechanical Comprehension	0.13	0.30	0.29	—0.26	0.53	

*The reader is referred to Tiffin, J., "Industrial Psychology", 1942, pages 42-47, for explanation, and to Garrett "Statistics in Psychology and Education", 1937, page 344.

Since the *r*'s reveal production manager interest (Strong) 0.38, personality (Bernreuter) 0.36, occupational level of interests (Strong) .22, and mechanical comprehension (Bennett) 0.11, scores were weighted by rounding of each *r* in its relation to each test and the criterion. The formula, then, for each leader's score becomes L equals 4 (production manager T-score) plus 3 (personality T-score) plus 2 (occupational level T-score) plus 1 (mechanical comprehension T-score) over 10; or:

$$L = \frac{4(PM) + 3(PS) + 2(OL) + 1(MC)}{10}$$

A new T-score results from combinations of previous T-scores. These combined T-scores were thrown into a new distribution and new standard deviations or sigmas calculated.

When these combined T-scores were correlated with the criterion ratings, the correlation coefficient equals 0.52, and when corrected for attenuation becomes 0.60.

The Taylor-Russell tables indicate that with the correlation coefficient of the combined test battery at 0.60 and a large employee group from which to select leaders, at least 89% of any new leaders selected by this battery under these same conditions would make satisfactory leaders. If the raw unattenuated correlation coefficient of 0.52 is used in entering the tables, 81% of the new leaders selected would be satisfactory, according to the tables.*

The efficiency of the four-test battery can be validated in another way. If the positions of these thirty men are plotted on a scatter diagram with the criterion ratings on one axis and the combined T-scores of the tests on the other, 80% of thirty leaders are placed correctly in their proper quadrants. In other words, the criterion ratings of the management, arrived at in the manner herein described, agreed with the test results to the extent of 24 of the 30 subjects. Only six men were displaced by the tests. Out of the 14 men who appear above average in the tests, 11 are rated above average by management.

The company can safely place any individual who scores 50 on the combined T-score in a "pool" for replacement and upgrading.

Conclusions

Under the conditions existing at the present time in the Coleman plant, this study of these thirty men by this battery of test reveals the following facts:

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*For explanation of Taylor-Russell tables, see Tiffin, J., "Industrial Psychology", 1942, page 41.

1. That the two schedules from the *Strong Vocational Interest Blank,* namely, the "Production Manager Interest" and "Occupational Level of Interests," the total score of the *Bernreuter Test* and the *Bennett Mechanical Comprehension Test* constitute with the method used the best composite battery for selecting leaders from Coleman employees in relation to the criterion.
2. That the efficiency of this battery in accordance with Taylor-Russell tables is at least 80 per cent for selecting foremen from lower ranks, i.e., gang leaders and supervisors.
3. Any individual who makes a combined T-score of 50 on this battery is a potential leader and can become a member of a "pool" for future replacement and upgrading.
4. The method described here is valid under the conditions in which this study is made, but it should be subject to further validation when used as a tool for selection and replacement.

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Kansas Botanical Notes: 1944[1]

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At Manhattan, 1944 was a wet year, having over half again as much precipitation as normal and just missing all-time high records for rainfall in April, in August, and for the year as a whole. The temperatures were for the whole year just a trifle above normal.

In the spring the dates of first blossoming were in general very late, in fact for more than half of the species under observation, the latest observed since this series of records was begun in 1929. In five other cases the record for latest flowering was tied. Since such extreme lateness was so widespread, it may be worth while including the dates in these notes.

Acer ginnala, May 10
Acer negundo, April 17
Acer platanoides, April 24
Aesculus glabra, May 8
Androsace occidentalis, April 24
Antennaria campestris, April 23
Aquilegia latiuscula, May 10
Asimina triloba, April 29
Asparagus officinalis shoots, April 24
Baptisia minor, May 15
Baptisia leucophaea, May 15
Berberis thunbergii, May 3
Berberis vulgaris, May 11
Callirhoe involucrata, May 26
Corydalis micrantha, April 23
Catalpa speciosa, June 4
Celtis occidentalis, May 8
Chaenomeles lagenaria, April 15
Convallaria majalis, May 10
Crataegus sp., May 11
Elaeagnus angustifolia, May 27
Hordeum pusillum, May 18
Iris germanica, May 15
Iris pumila, April 20
Juglans nigra, May 13
Lappula echinata, May 27
Lepidium densiflorum, May 22
Medicago sativa, May 27
Mirabilis nyctaginea, May 26
Opuntia megarhiza, June 5
Oxalis stricta, May 9
Oxalis violacea, May 8
Pinus sylvestris, May 12
Pisum sativum, May 17
Populus sargentii, April 18
Prunus angustifolia watsoni, April 26
Prunus armeniaca, April 24
Prunus cerasus, May 8
Prunus trifolia, April 29
Prunus virginiana, May 9
Quercus imbricaria, May 5
Quercus macrocarpa, May 2
Quercus maxima, May 3
Quercus muhlenbergii, April 29
Quercus palustris, May 10
Rorippa sinuata, May 15
Ribes odoratum, April 24
Robinia pseudoacacia, May 25
Senecio plattensis, May 15
Sisyrinchium campestre, May 15
Smilicina racemosa, May 10
Spiraea thunbergii, April 13
Syringa persica, May 1
Tradescantia tharpii, May 2
Trifolium pratense, May 23
Viburnum prunifolium, May 15
Vinca minor, April 26
Viola papilionacea, April 24
Zygadenus nuttallii, May 18

In the spring, fruits of elm were scarce because in the warm

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[1]Contribution No. 466 from the Department of Botany and Plant Pathology, Kansas State College of Agriculture and Applied Science.

weather in January flowering buds in large numbers all but burst into bloom—in fact, some did bloom in late January. Prolonged severe cold weather in February killed most of the twigs with swollen buds outright. A separation layer was former at the base of these twigs, resulting in the shedding of huge numbers of short twigs. When spring did finally arrive, a few dormant buds developed, making comparatively few flowers and very little fruit.

Great quantities of the two worst spring lawn weeds, *Lamium amplexicaule* and *Stellaria media,* were very much in evidence for a longer time than for any spring since we have been writing these notes. At the end of the third week in May, Stellaria, which has usually disappeared by this time from most places, was yellowish in dying to the ground. From a distance it seemed that there were large patches of dodder in many lawns.

Miss Jacobs reported that a catalpa tree on the campus bloomed off and on thru June, July, and August, something never before noticed.

During the year but little attention could be paid to collecting activity, although a few specimens were received as additions to county records from John Hancin, from Saline County; Don Stallings, from Sumner County; Don Cornelius, of the Soil Conservation Service, from different counties; Bernard Rohrer, from Miami County; and a large series of up-to-date specimens from S. V. Fraser, from Cloud County.

A single plant of *Daubentonia longifolia,* a not uncommon Gulf Coast legume, appeared in the back yard of A. O. Lewis, Parsons, Labette County. The plant developed to a height of 7 feet and bore small yellow flowers but did not mature fruit.

The poisonous plant, *Suckleya suckleyana* (Chenopodiaceae), is not uncommon in northeastern Colorado and adjacent Wyoming and Nebraska. As far as we can tell it made its first appearance in Kansas during the summer of 1944, altho it had been collected within a mile or two of the state border in 1942. With its appearance this year around waterholes in the high plains near Syracuse, Hamilton County, during the dry autumn, cattle poisoning took place. While the total number of cattle that died as a result of eating it is not known, the county agent, Frank Bieberly, reported deaths of 10 cattle and said that other cases were known in the general region. The plant poisons as a result of the liberation of hydrocyanic acid in the animals consuming it. A warning was issued thru the farm

papers and over the radio to extreme western Kansas.

Late in 1944, Mr. C. M. Slagg, while driving thru Haskell County in southwestern Kansas, noticed a white appearance on a grain sorghum field. Thinking it might be some new disease, he investigated only to find that a fire along the fence row had popped the sorghum kernels of the plants close to the fence row. The popped grain is about 5-7 mm. across and 4-5 mm. high. The taste of the popped sorghum is similar to that of ordinary popcorn, particularly like the popcorn grains which have roasted and cracked but have not popped out fully.

Quoting from a letter from Don B. Stallings, of Caldwell, Kansas:

"One thing of interest. The various sunflowers in this vicinity this year had an unusual number of flowers that were 'doubled' in fact in some the brown center was covered over with additional yellow petals. There were so many of them around here that we had several folks, not particularly interested in them, comment on them. That fact alone may not be particularly interesting but coupled with a second fact in the field of entomology it seems to me that there is something of interest going on this year. *Strymon alcestis* is a butterfly that is normally very constant—in a good colony of them I have seen as many as 500 at a time and all as alike as peas in a pod—still this year we took 4 extreme aberrations. *Minois alope texana* is a very variable butterfly—but this year you couldn't get two alike. Other species this year showed more variance from normal than in any year previous. From those few facts it would seem that in Sumner County this year conditions were right for aberrations. I wonder why?"

In the autumn, frost held off an abnormally long time, much later than any previous year in our experience. While light touches of frost were experienced in the vicinity of Manhattan the 10th of November, actual killing frost in Manhattan did not occur until November 20, more than a month after normal killing frost, and 18 days later than previously recorded in these observations. On November 9 the following plants in gardens, lawns, and waste places were found in bloom. On November 13 nine of them were still in blossom and on November 18 ten were in blossom. As this is so much later than one would expect, the list is given in full.*

*Compare this list with that given by Professor Agrelius for Lyon County in these *Transactions*, volume 48, p. 105, 1945.

PLANTS IN BLOSSOM ON NOVEMBER, 1944, DATES

	November, 1944			
Calendula	9			18
Canna edulis	9		13	18
Chaenomeles lagenaria	9			
Chrysanthemum spp.	9		13	18
Cosmos sp.	9		13	18
Eleusine indica	9			
Forsythia suspensa	9			
Ipomoea hederacea	9			18
Lonicera sp.	9	10		
Lycopersicum esculentum	9			
Petunia axillaris	9		13	18
Phaseolus vulgaris	9			
Ricinus communis	9		13	18
Rosa sp.	9			
Solanum nigrum	9		13	
Stellaria media	9		13	18
Taraxacum laevigatum	9		13	18
Tropaeolum minus	9			
Viola missouriensis	9			
Zinnia sp.	9		13	18

An interesting instance of a crescentic annual increment occurred in Manhattan. About two-thirds of the top of a 22-year-old branch on a 30-year-old elm tree (*Ulmus americana*) was cut off late in 1943. On the lower outside part of this stub near the tip, two adventitious buds produced branches, the longer of which exceeded 2 meters. In December, 1944, the stub itself was cut off. Examination of the cut end disclosed that, for about 20° each way, directly below the branch there was a crescent of wood equal in its greatest width to annual increments of earlier years. There was no other 1944 wood on the stub.

The Electrodeposition of Lead in the Presence of Wetting Agents

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The deposition of lead on lead cathodes from a solution of lead nitrate alone yields a rough grained, rather dark deposit of poor adherence. Under ordinary conditions of current density and concentration of lead there is excessive "treeing" around the edges and on the corners of the cathode. Because of such poor deposits from simple lead nitrate solutions, in the commercial plating of lead fluorosilicate, fluoborate, or perchlorate baths are used since these have been found to give smoother and more adherent deposits. Because of cost and the fact that lead is very easily applied by dipping methods, electroplating is used only in special cases.[1]

Early work on the use of addition agents in lead plating has been reviewed by Taft and Finke.(2) More recent studies include the effect of addition agents in lead sulfamate,(3) lead acetate,(4) and alkaline(5-6) baths.

The historical background and the special considerations necessary for the use of wetting agents in electroplating baths have been adequately covered by Taft and Hiebert(7) and will not be repeated here.

The purpose of this study was to determine the effect of various wetting agents on the form of electrodeposited lead and is similar to the work done by Taft and Hiebert(7) on silver. A search of the literature failed to show any use of wetting agents in the deposition of lead from lead nitrate solutions.

Experimental Procedure

Part A of this study is a comparison of 118 agents under similar conditions; part B is the further investigation of several selected agents under varied conditions.

The experimental procedure for part A was the same as that used by Taft and Finke,(2) namely a current density of 2.0 amperes/dm^2; a temperature of 30°C.; a concentration of lead nitrate 1.4 molal; and a concentration of the wetting agent 0.1% by weight.

The specific gravity of a 1.4 molal solution of lead nitrate is 1.35; hence 0.135 grams of the wetting agent was added to each 100

ml. of the stock solution. Controls consisted of the stock solution with no agent added.

Of the 118 wetting agents tried about two-thirds gave precipitates with the lead nitrate solution. These solutions were allowed to stand until they became clear; the solution used in the electrolytic cells was then pipetted from the clear, supernatant solution.

Both cathodes and anodes consisted of sheet lead. The cathodes were 2.5 x 2.5 cm. square (or 6.25 cm^2 area) and were cut with stems of the same material. Both cathodes and anodes were cleaned with dilute nitric acid and rinsed repeatedly with distilled water before use.

Electrolysis was carried out in 100 ml. beakers filled with approximately 75 ml. of solution and suspended in a constant temperature bath by means of a special rack. All solutions were run in duplicate and two controls were run with each group of 12 cells. If there was any question concerning the form of the deposit, duplicate samples were rerun. The electrodes were placed about 2.5 cm. apart in the cells.

In order to have a current density of 2 amperes/dm^2 a current of 0.1875 amperes was used. This value was calculated by assuming that the effective area of the electrode was 1.5 times the face area of 6.25 cm^2. The current was measured by an ammeter and kept constant with a variable resistance. Electrolysis was carried out for 25 minutes, thus giving a deposit of approximately 0.3 grams. After electrolysis, the electrodes were rinsed by carefully dipping the electrode in distilled water and allowing them to dry before comparisons were made with the controls.

Much difficulty was encountered in weighing the deposits. In most cases, part of the deposit dropped off, either in the plating cell or during rinsing after electrolysis. However, weights were obtained on about 30 of the more adherent deposits. In order to compare the masses, all values were calculated to a standard mass of 0.3000 grams in the control, by means of the relation

$$\text{Computed mass} = \frac{\text{Average mass of duplicate deposits}}{\text{Average mass of control deposits}} \times .3000$$

Each deposit was carefully compared with the control deposit. Special attention was given to color, adherency, coverage, form and size of crystals, and general form of deposits. Experimental data in part A for each wetting agent includes the weight of the deposit where possible, the condition of the solution (clear or cloudy), and notes on the deposit. Immediately under clear or cloudy will be noted "ppt.", "no ppt.", or "undis."; such notes indicating that the

wetting agent when added to the lead nitrate solution gave a precipitate, no precipitate, or was not soluble to the extent of 0.1% by weight respectively.

In part B of this investigation variation of current density, temperature, concentration of wetting agent, and concentration of lead nitrate were carried out on several selected wetting agents and on several commercial baths. All the conditions are listed in the experimental data and all references to control are to the controls run at the corresponding temperature and current density.

Fatty Acid Salts and Soaps

Ref. No.	Wetting Agent	Wt. of Deposit (gm.)	Solution	Notes on Deposits
1.	Ammonium Laurate	0.3049	clear ppt.	Slightly finer crystals than control, otherwise same.
2.	Ammonium stearate	--------	clear ppt.	Control.
3.	Potassium oleo-abietate (Miscibol)	0.3010	clear ppt.	Slightly finer crystals than control, more adherent, more treeing, cracks on bending.
4.	Ivory Soap	--------	clear ppt.	Coarser crystals than control, otherwise same.
5.	Oxydol	--------	clear ppt.	Same as (4).
6.	Rinso	--------	clear ppt.	Control but lighter color.
7.	Duz	--------	clear ppt.	Control.
8.	Cal-Soap (a drycleaning soap)	--------	clear ppt.	Same as (4).
9.	Sizeoff (a desizer for dry cleaning)	--------	clear ppt.	Control, more treeing.
10.	Williams Shaving Cream	--------	clear ppt.	Control.
11.	Mennen Brushless Shave Cream	--------	clear ppt.	Control, but poorer adherence.
12.	Molle Brushless Shave Cream	--------	clear ppt.	Control.
13.	Beacoscope A (a naphthenic soap)	--------	clear ppt.	Smooth deposit finer than control, good adherence but cracks on bending. Treeing same as control.
14.	Fatty acid salt of a substituted oxazoline (Aciterge Oil)	--------	clear undis.	Slightly finer than control but more treeing.
15.	Cation-active amino esters of long-chain fatty acids (Negamine No. 142A)	--------	clear ppt.	Finer and less treeing than control, poor adherence.
16.	Cation and anion active compound (Janusol)	--------	clear ppt.	Uneven and rougher than control, very poor adherence.
17.	Long-chain fatty acid basic amide (Intracal)	--------	clear ppt.	Control, but uneven and poor adherence.

Discussion—Fatty Acid Salts and Soaps

Ammonium laurate, potassium oleo-abietate, Beacoscope A, Aciterge oil, and Negamine No. 142 A gave deposits which were finer than the control. Of these, weights were obtained on the first three, ammonium laurate being greated by 0.0049 grams and Beacoscope A

being lighter by 0.0059 grams. Negamine No. 142A was the only one which showed less treeing than the control, but it was also the only one with poorer adherence.

The following soaps: Ivory, Oxydol, Rinso, Duz, Calsoap, Sizeoff; three shaving creams (10), (11), and (13); and ammonium stearate, gave deposits like or slightly coarser than control. None of these were more adherent or showed less treeing than the control.

Only one of the seventeen agents in this group, Aciterge oil, did not give a precipitate with 1.4 molal lead nitrate but it was not soluble to the extent of 0.1% by weight.

The Sulfonates

Ref. No.	Wetting Agent	Wt. of Deposit (gm.)	Solution	Notes on Deposits
1.	Sodium alkyl naphthalene sulfonate (Alkanol B)	....	clear ppt.	Large coarse crystals, very poor adherence; most of the deposit dropped off in plating bath.
2.	Sodium alkyl naphthalene sulfonate (Alkanol SA)	....	clear ppt.	Large loose crystals, poor adherence, poor coverage; some dropped off in plating bath.
3.	Sodium alkyl naphthalene sulfonate plus a fungacide (Alkanol HG)	0.4139	clear ppt.	Fluffy even deposit about 7 mm. deep on electrode, collapses on removal from bath, poor adherence, no treeing.
4.	Sodium tetrahydro naphthalene sulfonate (Alkanol S)	....	clear no ppt.	Control, but extensive treeing.
5.	Sodium Alkyl naphthalene sulfonate (Nekal A)	....	clear ppt.	Large flat crystals, poor adherence, rubs off easily, extensive treeing.
6.	(Nekal AEMA)	0.2933	cloudy ppt.	Smooth even deposit, slight treeing on corners, fine crystals, slight discoloration.
7.	Sodium sulfonate of petroleum hydrocarbons (Ultra-wet)	0.2955	clear ppt.	Very fine even deposit, lighter than control, good adherence and coverage; a few fine trees on corners, does not crack on bending.
8.	Sodium sulfonates in a paraffin oil (Stanco Soap Product 302)	0.2975	clear undis.	Control, but slightly finer crystals.
	Sodium sulfonates of petroleum (Stanco Soap Product 702)	0.3005	clear undis.	Finer crystals and more treeing than (8).
10.	Sodium alkyl naphthalene sulfonate (Neomerpin N)	....	clear ppt.	Same as (2).
11.	Sodium alkyl phenylene sulfonate (Invadine B)	....	clear ppt.	Coarser than control, poor adherence; some dropped off in plating bath.
12.	Sodium alkyl naphthalene sulfonate (Invadine C)	0.2994	cloudy ppt.	Crystals finer than control, slightly striated, fine trees, colored deposit.
13.	Sodium alkyl naphthalene sulfonate (Invadine N)	....	cloudy ppt.	Loose rough deposit, poor adherence, rubs off easily.
14.	Salt of substituted aromatic sulfonic acid (neutral) (Santomerse 1)	....	clear ppt.	Uneven deposit coarser than control, poor adherence.
15.	Same (alkaline) (Santomerse 2)	....	clear ppt.	Slightly coarser than control, poor adherence.
16.	Same (neutral) (Santomerse 3)	0.2999	clear ppt.	Crystals finer than control, fair adherence, slight striations.
17.	Same (neutral) (Santomerse D)	....	clear ppt.	Coarser than (16), poor adherence.

Ref. No.	Wetting Agent	Wt. of Deposit (gm.)	Solution	Notes on Deposits
18.	Sodium mono-sulfonate of mono-butyl phenyl phenol (Areskap)	....	clear ppt.	Loose fluffy trees, poor adherence and coverage, slightly striated.
19.	Sodium mono-sulfonate of mono-butyl diphenyl (Aresket)	....	clear ppt.	Large flat crystals, very poor adherence and coverage.
20.	Sodium disulfonate of dibutyl phenyl phenol (Aresklene)	....	clear undis.	Large fluffy flat crystals, poor adherence, darker than control.
21.	Sodium isopropyl naphthalene sulfonate (Aerosol OS)	0.2887	clear ppt.	Crystals finer than control, short fine trees, slightly striated, colored deposit.
22.	Mono-ethyl phenyl phenol sodium mono-sulfonate (Beaconol A)	....	clear ppt.	Slightly finer than control, extensive treeing, poor coverage.
23.	Mono-ethyl phenyl phenol Aminomonosulfonate (Beaconol S)	0.3018	clear undis.	Slightly finer and less treeing than control, darker than control.
24.	Mono-ethyl phenyl phenol quanidine monosulfonate (Beaconol T)	0.3037	clear undis.	Finer than control, but more treeing; lighter color than control.
25.	Mono-ethyl phenyl phenol potassium monosulfonate (Beaconol M)	....	clear undis.	Control.
26.	Mixture of hydrocarbon sulfonate and a substituted aminodioxane (Wetting Agent 5-21)	0.2978	clear undis.	Same as (24) except definite striae.
27.	Sodium salt of sulfonated lauryl and myristyl colomide (Intramine Y)	....	clear ppt.	More but shorter trees than control, poor coverage, otherwise control.
28.	Same (Intramine WK)	....	clear ppt.	Same as (27) but slightly coarser and better coverage.
29.	Sodium and potassium salts of sulforicinoleic acids	....	clear undis.	Control.

Discussion—The Sulfonates

It is entirely possible that some of the sulfonates should be placed in the sulfate group and vice versa as commercial nomenclature often does not distinguish clearly between the two. This group of sulfonates is unique in that it contains not only the poorest, but also the best, deposits which were obtained in this investigation.

Eleven out of this group of twenty-nine gave deposits which were finer than the control. These eleven were: Nekal AEMA, Ultrawet, Stanco Soap Product 302, Stanco Soap Product 702, Invadine C, Santomerse 3, Aerosol O.S., Beaconol A, Beaconol S, Beaconol T, and Wetting Agent 5-21. Of these eleven, only two gave deposits which were outstanding: Nekal AEMA and Ultrawet. Both of these were smooth, even deposits with fine crystals, and had only slight treeing on the corners of the cathode. Four of these eleven showed a definite tendency toward forming striated deposits. They were Invadine C, Santomerse 3, Aerosol O.S., and Wetting Agent 5-21.

Of the remaining eighteen deposits, half were approximately of the same form as the control. The other half can be characterized as producing fluffy, bulky deposits with coarse crystals of very poor adherence, some of the deposit being dropped in the plating bath. Only one of these, Areskap, had a tendency to give a striated deposit.

Weights were obtained on eleven deposits, none of them varying greatly from the control except Alkanol HG. This deposit was 0.1139 grams heavy, which would be expected from the fluffy even deposit about 7 mm. deep on the electrode. The excess weight was probably due to enclosed salts which were not removed on washing.

ESTERS OF SODIUM SULFOSUCCINATE
(The Aerosols)

Ref. No.	Wetting Agent	Wt. of Deposit (gm.)	Solution	Notes on Deposits
1.	Dibutyl ester of sodium sulfosuccinate (Aerosol 1B)	....	clear no ppt.	Control, but poorer adherence.
2.	Diamyl ester of sodium sulfosuccinate (Aerosol AY)	....	clear no ppt.	Same as (1) except slightly lighter and larger trees.
3.	Dihexyl ester of sodium sulfosuccinate (Aerosol MA)	....	clear ppt.	Loose large crystals, very poor adherence, some dropped off in plating bath.
4.	Dioctyl ester of sodium sulfosuccinate (Aerosol O.T.)	0.3025	clear undis.	Crystals slightly finer than control, fair adherence, more treeing than control.
5.	Sulfonated ester of dicarboxylic acid (Betasol O.T.)	0.3022	clear no ppt.	Same as (4).
6.	Sodium and potassium salts of sulfonated esters of dicarboxylic acids. Penatrol 60)	....	clear undis.	Loose flat crystals, coarser than control, poor adherence.

Discussion—The Aerosols

The first four members of this group are all esters of sodium sulfosuccinate, which has a general structure of

$$\begin{array}{l} CH_2COO(CH_2)_nCH_3 \\ | \\ CH(SO_3Na)(CH_2)_mCH_3 \end{array}$$

ranging from the dibutyl ester to the dioctyl ester. Of these, the dihexyl ester (Aerosol AEMA) gave the poorest deposit and the dioctyl ester (Aerosol OT) gave the best deposit. Both the dibutyl and the diamyl esters gave deposits similar to the control except for poorer adherence.

Weights were obtained on two of the deposits in this group. Both agreed very closely with the control. Only one of this group, Aerosol MA, gave a percipitate with 1.4 molal lead nitrate solution.

Two, Aerosol OT and Penetrol 60, were not soluble to the extent og 0.1% by weight.

Sodium Fatty Acid Esters and Amides
(The Igepons)

Ref. No.	Wetting Agent	Wt. of Deposit (gm.)	Solution	Notes on Deposits
1.	Sodium fatty acid ester sulfonate $C_{17}H_{33}COOC_2H_4SO_3Na$ (Arctic Syntex A)	--------	clear ppt.	Control.
2.	Sodium fatty acid ester sulfate $RCOO(CH_2)nSO_4Na$ (Wetanol)	0.2988	clear ppt.	Control but slightly finer crystals.
3.	$CH_3(CH_2)_{10}COOCH_2$-$CHOCH_2SO_4Na$ (Arctic Syntex M)	--------	cloudy ppt.	Control, but slightly darker in color.
4.	Sodium fatty acid acid amido-sulfonate $C_{17}H_{33}CONCH_2H_4$-SO_3Na (Arctic Syntex T)	--------	clear ppt.	Poorer adherence than control, otherwise same.
5.	$C_{17}H_{33}CONHC_3C_2H_4SO_3Na$ (Igepon T)	--------	cloudy ppt.	Same as (4) except slightly less treeing.

Discussion—The Igepons

This group in general had very little effect on the form of the deposit; only one, Wetanol, giving a deposit slightly finer than the control. All five gave precipitates in 1.4 molal lead nitrate solution. Only one was weighed (Wetanol). Its mass was close to that of the control.

The Sulfates

Ref. No.	Wetting Agent	Wt. of Deposit (gm.)	Solution	Notes on Deposits
1.	Sodium lauryl sulfate (Dreft)	--------	clear ppt.	Control, slightly poorer adherence.
2.	Sodium lauryl sulfate (technical) (Arvus)	--------	clear ppt.	Control.
3.	Sodium lauryl sulfate (technical) (Duponol WA)	--------	clear ppt.	Same as (1).
4.	Sodium oleyl sulfate (Duponol LS)	0.3006	cloudy ppt.	Slightly more treeing and slightly finer crystals than control.
5.	Long-chain alcohol sulfate (Duponol 80)	--------	clear ppt.	More treeing but crystals same as control, deposit rather spotted.
6.	Long-chain alcohol sulfate (Duponol L-144)	--------	clear undis.	Control.
7.	Sodium oleyl sulfate plus a synthetic resinous sticker. (Grasselli Spreader Sticker)	--------	clear undis.	Very slightly finer and lighter in color than control, otherwise same.
8.	An alkyl sulfate (Dupont In-3622)	--------	clear ppt.	Crystals slightly larger than control, poor adherence and coverage.
9.	(Mercerol OS)	--------	clear undis.	Control, but poorer adherence.
10.	$C_4H_9CH(C_2H_5)$ CH_2SO_4Na (Tergitol Penetrant 08)	--------	clear ppt.	Slightly coarser than control.

Ref. No.	Wetting Agent	Wt. of Deposit (gm.)	Solution	Notes on Deposits
11.	$C_4H_9CH(C_2H_5)C_2H_4CHCH_2CH(CH_3)_2SO_4Na$ (Tergitol Penetrant 4)	0.3543	clear ppt.	Large flat fluffy crystals, darker than control.
12.	$C_4H_9CH(C_2H_5)C_2H_4CHC_2H_4CH(C_2H_5)_2SO_4Na$ (Tergitol Penetrant 7)	....	clear ppt.	Same as (10) but poorer adherence.

Discussion—The Sulfates

The sulfates from 1 to 10 are similar in composition and gave very similar deposits, all of them being like the control or slightly coarser except Duponol LS and Grasselli Spreader Sticker. These two were slightly finer. The last three, Tergitol Penetrant 08, Tergitol Penetrant 4, and Tergitol Penetrant 7 are sodium sulfates of higher synthetic alcohols. Tergitol 08 (10), the smallest and least branched molecule, gave the best deposit of the three, while Tergitol 7 (12), the largest and most branched, gave the poorest deposit. All of these sulfates either gave a precipitate or were not soluble to the extent of 0.1%. Only two of the deposits were weighed, Duponol LS and Tergitol Penetrant 4. Duponol LS was very close to the mass of the control, but that of Tergitol Penetrant 4 was 0.0543 grams higher, as would be indicated by the type of deposit.

Alcohol and Polyalcohol Derivatives

Ref. No	Wetting Agent	Wt. of Deposit (gm.)	Solution	Notes on Deposits
1.	Fatty acid salt of 2-Amino-2-Methyl-1-propanol	....	clear ppt.	Control.
2.	Fatty acid salt of 2-Amino-2-Methyl-1,3 propanediol	....	clear ppt.	Control but slightly more treeing.
3.	Tris (hydroxy-methyl) amino methane	....	clear ppt.	Slightly more adherent than control, otherwise same.
4.	Condensation product of ethylene oxide and an organic acid (Emulphor ELA)	0.2983	clear no ppt.	Slightly finer crystals than control, otherwise same.
5.	Same (Emulphor AG Oil)	....	clear undis.	Control.
6.	Diglycol laurate	....	clear ppt.	Same as (2).
7.	Glyceryl mono-laurate	....	clear ppt.	Slightly coarser than control and less adherent.
8.	Propylene laurate	....	clear undis.	Control.
9.	Glyco-Stearin	....	clear ppt.	Larger finer trees than control, otherwise same.
10.	Diglycol stearate	....	clear ppt.	Control, but slightly less treeing.
11.	Diglycol oleate	0.3067	clear undis.	Slightly finer crystals than control, fair adherence.
12.	Glyceryl mono-stearate	....	clear undis.	Control.
13.	Glyceryl mono-ricinoleate	....	clear undis.	Slightly coarser than control.
14.	Sulfated glyceryl amide (Alframine DCA)	....	clear ppt.	Control.
15.	Aminostearin	....	clear ppt.	Control.

Ref. No.	Wetting Agent	Wt. of Deposit (gm.)	Solution	Notes on Deposits
16.	Sorbitan monolaurate (Atlas G-759)	....	clear undis.	Slightly coarser and darker than control.
17.	Mannitan monolaurate (Atlas G-772)	0 3053	clear undis.	Slightly finer than control, fair coverage and adherence.
18.	Sorbitan monoleate (Atlas G-944)	....	clear undis.	Slightly more treeing than control, otherwise same.
19.	Phosphorated higher alcohol $(octyl)_5Na_5P_6O_{20}$ (Wetting Agent 35-B)	....	clear ppt.	More trees but better adherency than control.
20.	Phosphorated higher alcohol $(capryl)_5Na_5P_6O_{20}$ (Wetting Agent 58-B)	....	clear ppt.	Slightly finer crystals than control, otherwise same.
21.	Substituted amide of alkyl phosphate (12 carbon) (Cationic Agent C)	....	clear ppt.	Crystals coarser and more uneven than control, poor adherence.
22.	Substituted amide of alkyl phosphate (18 carbons) (Cationic Agent D)	....	clear ppt.	Control, but slightly better adherence.
23.	Anhydrohexitol partial oleate (Arlacel C)	....	clear undis.	Slightly coarser and darker than control, otherwise same.
24.	Hexitan partial fatty acid ester (NNOR)	....	clear ppt.	Deposit uneven and rougher than control, poor adherence.
25.	Substituted hydrocarbon (Resolin B Paste)	0.2883	clear ppt.	Lighter than control, finer crystals, good adherence, some treeing, definite striations.

Discussion—Alcohol and Polyalcohol Derivatives

The classification above is somewhat arbitrary. It does provide a place for some wetting agents which would be difficult to classify otherwise. Only one of this group was completely soluble in lead nitrate without a precipitate—Emulphor ELA. Five of the deposits were finer than the control. They were (4), (11), (17), (20), and (25). All of the remaining deposits were either similar to the control or slightly coarser. Resolin D Paste (25) gave the best deposit in the group. It was also the only one which showed a definite tendency to form a striated deposit.

Ether Derivatives

Ref. No.	Wetting Agent	Wt. of Deposit (gm.)	Solution	Notes on Deposits
1.	Sodium alkyl aryl ether sulfate (Triton W-30)	....	clear undis.	Darker and more spotted than control, otherwise same.
2.	Sodium alkyl aryl polyether sulfonate (Triton 720)	....	clear ppt.	Control, slightly better adherence.
3.	Amine salt of alkyl phenolic ether sulfate (Triton E-79)	....	cloudy ppt.	Loose flat crystals, poor adherence.
4.	Organic polyether alcohol (Triton NE)	0.3015	clear no ppt.	Slightly finer crystals than control.
5.	(Triton K-12)	0.3024	clear undis.	Slightly finer than control, short, fuzzy trees.
6.	Polyoxyalkylene ether of partial lauric acide ester (Tween 20)	0.3052	clear no ppt.	Slightly darker and finer than control, rather fuzzy trees.
7.	Polyoxyalkylene ether of partial palmitic acid ester (Tween 40)	....	clear ppt.	Somewhat coarser and rougher than control.
8.	Polyoxyalkylene ether of partial stearic acid ester (Tween 60)	....	clear ppt.	Like control but slightly uneven.

Ref. No.	Wetting Agent	Wt. of Deposit (gm.)	Solution	Notes on Deposits
9.	Polyoxyalkylene ether of partial oleic acid ester (Tween 80)	--------	clear no ppt.	Spotted, poor coverage; finer in spots than control but more treeing.
10.	Polyethers (Intral No. 224)	--------	clear undis	Uneven and rough, short fuzzy trees, poor adherence and coverage.

Discussion—Ether Derivatives

Several of these substances were soluble and gave no precipitate in 1.4 molal lead nitrate solution. They were Triton NE, Tween 20, and Tween 80. Three, Triton NE, Triton K-12, and Tween 20, gave deposits which were slightly finer than the control. The deposits from these three were weighed and did not vary greatly from the mass of the control. The rest of the deposits were essentially similar to the control except Intral 224 (a mixture of polyethers) which gave a rough, uneven, poorly adherent deposit.

Unclassified Wetting Agents

Ref. No.	Wetting Agent	Wt. of Deposit (gm.)	Solution	Notes on Deposits
1.	Nelgin	--------	clear ppt.	Control, slightly less treeing.
2.	Proflex	0.3023	clear ppt.	Fine smooth deposit but extensive treeing; good adherence.
3.	Blendene	--------	clear undis.	Slightly coarser and more uneven than control.
4.	Hydromalin	--------	clear ppt.	Slightly finer than control.
5.	Emulsone B (a vegetable gum)	0.3030	clear ppt.	Same as (2).
6.	Abopon	--------	clear ppt.	Somewhat coarser than control, otherwise same.
7.	Virifoam A	--------	Clear ppt.	Finer crystals than control, poorer adherence, colored deposit.
8.	Carbowax 4000	0.3028	clear ppt.	Finer and lighter color than control, same treeing.
9.	Mulsor 3 CW	--------	clear undis.	Spotted, crystals larger than control, poor adherence.
10.	Sandozol N	--------	clear undis.	Coarser than control, poor adherence.
11.	Rinfors L	--------	clear ppt.	Control but slightly lighter in color.
12.	Sandopan A	--------	clear ppt.	Control, but more treeing.
13.	Aminine S	--------	clear ppt.	Coarser and darker than control, uneven, poor adherence.
14.	Ampo LA	--------	clear ppt.	Control, but slightly darker.

Discussion—Unclassified Wetting Agents

The compositions of these wetting agents was not known. Most of the deposits were quite similar to the control. (2), (4), (5), (7), and (8) gave deposits finer than the control. Of these five (2), (5), and (8) were adherent enough to obtain weights on the deposits. They did not differ greatly from the mass of the control. All of these wetting agents either gave a precipitate or were not soluble to the extent of 0.1% by weight in 1.4 molal lead nitrate solution.

PART B

As already pointed out, in Part B there has been a more extensive investigation of the types of deposits from several of the foregoing wetting agents. The wetting agents selected for this purpose were Proflex, Triton NE, Nekal AEME, and Ultrawet. Variations were made in temperature, in concentration of wetting agent, in concentration of lead nitrate, and in current densities. When current densities were varied the time of deposition was adjusted so the mass of the deposit would remain the same (0.30 gm.) for all trials. The conditions under which each deposit was formed are listed in the experimental data. Where comparisons with a control are made, the control was deposited at the same temperature and current density; all control baths were 1.4 molal lead nitrate with no wetting agent added.

CONTROLS

Ref. No.	Con. of Wetting Agent (%)	Current Density (Amps./dm²)	Temperature (°C)	Notes on Deposits
1.	0.0	1.0	30.0	Coarser crystals than (2) but less treeing.
2.	0.0	2.0	30.0	Regular.
3.	0.0	3.0	30.0	More treeing than (2).
4.	0.0	4.0	30.0	Somewhat finer than (2). More treeing than (3).
5.	0.0	1.0	45.0	Coarser crystals than (1).
6.	0.0	2.0	45.0	Coarser crystals than (2), but finer than (5).
7.	0.0	1.0	0.0	Rougher than (8) but less treeing.
8.	0.0	2.0	0.0	Finer than (2) and about the same treeing.
9.	0.0	4.0	0.0	Finer than (8) but more treeing.

PROFLEX

Ref. No.	Con. of Wetting Agent (%)	Current Density (Amps./dm²)	Temperature (°C)	Notes on Deposits
1.	0.1	2.0	30.0	Fine smooth gray deposit, good adherency, but considerable treeing.
2.	1.0	2.0	30.0	Somewhat finer than (1); treeing only on corners.
3.	0.1	1.0	30.0	Crystals slightly larger than (1); less treeing than (1).
4.	1.0	1.0	30.0	Less treeing than (2); crystals finer than (3).
5.	0.1	2.0	45.0	Rougher and poorer adherence than (1); same treeing.
6.	1.0	2.0	45.0	Rougher and poorer adherence than (2); more treeing.
7.	0.1	1.0	0.0	Short trees on corners, about as smooth as (1) but poorer adherence and throwing power.
8.	1.0	1.0	0.0	Only 2 short trees, slightly smoother, better adherence and throwing power than (7).
9.	0.1	2.0	0.0	Smoother than (1) but slightly more treeing.
10.	1.0	2.0	0.0	Shiny deposit in spots, good adherence but not very good throwing power.
11.	0.1	4.0	0.0	Extensive treeing (clear across bath) but finer than (9).
12.	1.0	4.0	0.0	Shiny, smooth deposit; treeing less than (11).

Discussion—Proflex

The type of deposit produced by this wetting agent at conditions of 0.1% wetting agent, 1.4 molal lead nitrate, current density of 2 amps/dm², and 30°C, was a fine, smooth deposit of good adherency. It was representative of a large number of deposits in that treeing was the same as in the control. It was hoped that by varying conditions of deposition, treeing could be reduced. Increasing the current density, however, increased the treeing, but gave a slightly finer deposit. The best deposit obtained by varying conditions was number 8, which had only two short trees and was still a smooth, even deposit. This deposit was obtained with a low current density (1 amp/dm²) and low temperature (0°C).

Triton NE
(Organic Polyether Alcohol)

Ref. No.	Con. of Wetting Agent (%)	Current Density (Amps./dm²)	Temperature (°C)	Notes on Deposits
1.	0.1	2.0	30.0	Control, but slightly finer crystals.
2.	1.0	2.0	30 0	Finer and less treeing than (1).
3.	10.0	2.0	30.0	Finer than (2) but same treeing.
4.	0.1	1.0	30.0	Slightly rougher than control; short trees which fell off easily.
5.	1.0	1.0	30.0	Much finer than (4), slight fuzziness on edges, short fuzzy trees on corners.
6.	10.0	1.0	30.0	Finer than (5) but more treeing.
7.	0.1	2.0	45.0	Lighter color than (4).
8.	1.0	2.0	45.0	Brighter than (5), but slightly coarser crystals.
9.	10.0	2.0	45.0	Smooth shiny deposit but more treeing than (7).
10.	0.1	1.0	0.0	Control, but slightly rougher and slightly darker.
11.	1.0	1.0	0.0	Smoother than (10) but rougher than (2).
12.	10.0	1.0	0.0	Slightly fuzzy around edges; brighter than control.
13.	0.1	2.0	0.0	Control; trees on corners.
14.	1.0	2.0	0.0	Finer than and less treeing than (13)
15.	10 0	2.0	0.0	Smooth gray deposit; no trees on corners, but slight fuzziness around edges.
16.	0.1	4.0	0.0	Finer than (13) but extensive treeing.
17.	1.0	4.0	0.0	Same as (16) but less treeing.
18.	10.0	4.0	0.0	Finest deposit of batch; short trees on corners.

Discussion—Triton NE

Triton NE is a molasses brown, oily liquid; in composition an organic polyether alcohol, and is of the non-ionizing type. It gave no precipitate with 1.4 molal lead nitrate solution even in concentrations as high as 10% in weight. The type of deposit obtained is characteristic of the large number of the agents which gave deposits slightly finer than the control.

Here again decreasing the temperature or increasing the current density had the effect of decreasing crystal size. However, we find that at higher temperatuers, brighter deposits are obtained. The best deposit was number 18, secured at a current density of 4 amps/dm² and a temperature of 0°C. This deposit still treed on the corners.

Nekal AEMA

Ref. No.	Con. of Wetting Agent (%)	Molality $Pb(NO_3)_2$ solution	Current Density (Amps./dm²)	Temperature (°C)	Notes on Deposits
1.	0.01	1.4	2.0	30.0	Control but slightly finer.
2.	0.1	1.4	2.0	30.0	Fine, even deposit, very slight treeing on corners; slight brown discoloration.
3.	0.1	0.7	2.0	30.0	Slight striation, fluffy trees.
4.	1.0	1.4	2.0	30.0	Less treeing than (2), blue color.
5.	0.01	1.4	1.0	30.0	Smooth, gray; rather poor adherence.
6.	0.1	1.4	1.0	30.0	Slightly striated, rather poor adherence.
7.	0.1	0 7	1.0	30.0	Poor adherence, discolored, no striae.
8.	1.0	1.4	1.0	30.0	Very poor adherence, larger crystals than (2).
9.	0.01	1.4	4.0	30.0	Smooth, extensive treeing, no striae.
10.	0.1	0.7	4.0	30.0	Slight stria, fuzzy trees on corners.
11.	0.01	1.4	2 0	45.0	Poor adherence, fuzzy around edges.
12.	0.1	1.4	2.0	45.0	Poor adherence, not as much treeing as (13).
13.	0.1	.7	2.0	45.0	Very poor adherence, treeing.
14.	1.0	1.4	2.0	45.0	Dark, poor adhering deposit.
15.	0.01	1.4	1.0	45.0	Rougher than (11), otherwise same.
16.	0.1	.7	1.0	45 0	Rougher than (13), otherwise same.
17.	0.01	1 4	2.0	0 0	Shiny, no stria, fair adherence, trees on corners.
18.	0.1	1.4	2.0	0.0	Slight stria, good adherence but cracks on bending.
19.	0.1	0.7	2.0	0.0	Slight stria, treeing.
20.	1.0	1 4	2.0	0.0	No trees, no stria, slightly darker than control, cracks on bending.
21.	0.1	1.4	1.0	0 0	Definite stria, slightly rougher than (19), but less treeing.
22.	1.0	1.4	1.0	0.0	No trees, no stria, better adherence than (20).
23.	0.01	1.4	4.0	0.0	No stria, extensive treeing, fuzzy on edges.
24.	0.1	1.4	4 0	0 0	Short trees on edges, no stria, lighter than (26).
25.	0.1	0.7	4.0	0 0	Slight stria, fuzzy on edges.
26.	1.0	1.4	4.0	0.0	Very slight stria, even dark deposit, short trees.

Discussion—Nekal AEMA

This agent is of the sulfonate type and gave a precipitate with 1.4 molal lead nitrate solution. However, at 30°C, a current density of 2 amps./dm², and concentration of wetting agent 0.1% by weight, it gave the smooth type of deposit desired, with only very slight treeing on the corners.

With this agent an increase in temperature from 30° C to 40°C changed the deposit from a smooth adherent one to a thick, loose, very poorly adhering deposit. Decreasing the temperature or current density tended to give striated deposits. Increasing the concentration of wetting agent, especially at lower current density, gave non-striated deposits. Decreasing the concentration of lead nitrate tended to increase striations. The best deposit was number 22: con-

centration of wetting agent 1% by weight, 1.4 molal lead nitrate solution, current density 1 amp/dm², and temperature 0°C. This bath gave a deposit with no striations and no trees, fair adherence, but coarser crystals than some of the deposits.

Other trials made but not listed in the data consisted of stirring several of the baths with an ordinary L-type stirrer during deposition. The treeing on these deposits from stirred baths was approximately the same as that on deposits from baths without stirring. The trees, however, tended to follow the circulating liquid.

ULTRAWET

Ref. No.	Con. of Wetting Agent (%)	Molality $Pb(NO_3)_2$ solution	Current Density (Amps./dm²)	Temperature (°C)	Notes on Deposits
1.	0.01	1.4	2.0	30.0	Control, but slightly finer.
2.	0.1	1.4	2.0	30.0	Fine even deposit; a few short trees on corners; does not crack on bending.
3.	1.0	1.4	2.0	30.0	No treeing, smoother than (2), good throwing power.
4.	10.0	1.4	2.0	30.0	Very shiny, galvanized look; does not crack on bending.
5.	0.1	1.05	2.0	30.0	Same as (2).
6.	1.0	1.05	2.0	30.0	Same as (3).
7.	0.1	0.7	2.0	30.0	Slightly rougher and more treeing than (2).
8.	1.0	0.7	2.0	30.0	Same as (3).
9.	0.1	0.35	2.0	30.0	Fuzzy all around the edges; striated.
10.	1.0	0.35	2.0	30.0	Rougher than (8); no stria; a few short trees.
11.	0.01	1.4	1.0	30.0	No stria, gray; larger crystal size than (1).
12.	0.1	1.4	1.0	30.0	Finger marks, one tree only.
13.	1.0	1.4	1.0	30.0	No trees, slightly larger crystals than (3).
14.	10.0	1.4	1.0	30.0	Smooth, no trees, no stria, cracks on prolonged bending.
15.	0.1	1.05	1.0	30.0	Striated, bluish color, fuzzy on edges.
16.	1.0	1.05	1.0	30.0	No trees, shiny, smooth, no stria.
17.	0.1	0.7	1.0	30.0	Definite stria, bluish, fuzzy on edges.
18.	1.0	0.7	1.0	30.0	Smooth gray, no trees, no stria.
19.	0.1	0.35	1.0	30.0	Like (17) but slightly rougher.
20.	1.0	0.35	1.0	30.0	Smooth, fairly shiny, no trees, no stria.
21.	0.01	1.4	4.0	30.0	Same as (1) but more treeing.
22.	0.1	1.4	4.0	30.0	Same as (2) but more treeing.
23.	1.0	1.4	4.0	30.0	Shinier than (13) and smaller crystals.
24.	10.0	1.4	4.0	30.0	Same as (23).
25.	0.1	1.05	4.0	30.0	No stria, fuzzy on edges, short trees on corners, bluish purple color.
26.	1.0	1.05	4.0	30.0	Same as (23).
27.	0.1	0.7	4.0	30.0	Same as (25) but striated.
28.	1.0	0.7	4.0	30.0	No stria, slight trees on corners, and slight bluish color.
29.	0.1	0.35	4.0	30.0	Gray, striated, treeing on corners and fuzzy on edges.
30.	1.0	0.35	4.0	30.0	Same as (28) but grayish color and more treeing.
31.	0.01	1.4	2.0	45.0	Rough, short flat trees, no stria, gray color.

Ref. No.	Con. of Wetting Agent (%)	Molality $Pb(NO_3)_2$ solution	Current Density (Amps./dm^2)	Temperature (°C)	Notes on Deposits
32.	0.1	1.4	2.0	45.0	Same as (2) but more treeing and slightly smaller crystals.
33.	1.0	1.4	2.0	45.0	No trees, smooth bright deposit.
34.	10.0	1.4	2.0	45.0	Smooth, no trees, no stria, grayish but shines up on brushing.
35.	0.1	1.05	2.0	45.0	No stria, bluish, fuzzy around edges.
36.	1.0	1.05	2.0	45.0	No trees, no stria, shiny, does not crack on bending.
37.	0.1	0.7	2.0	45.0	Same as (35).
38.	1.0	0.7	2.0	45.0	Same as (36).
39.	0.1	0.35	2.0	45.0	Rough all over, short trees, fuzzy on the edges; no stria.
40.	1.0	0.35	2.0	45.0	Shiny, very short trees on corners.
41.	0.01	1.4	1.0	45.0	Rough, rather poor adherence.
42.	0.1	1.4	1.0	45.0	Same as (32).
43.	1.0	1.4	1.0	45.0	Same as (33).
44.	10.0	1.4	1.0	45.0	Same as (34)
45.	0.1	1.05	1.0	45.0	Same as (35) but slightly coarser.
46.	1.0	1.05	1.0	45.0	Same as (36).
47.	0.1	0.7	1.0	45.0	No stria, but slightly rough, fuzzy around edges.
48.	1.0	0.7	1.0	45.0	Same as (35).
49.	0.1	0.35	1.0	45.0	Rough, crystals sticking out from cathode; dark.
50.	1.0	0.35	1.0	45.0	No trees, shiny and smooth.
51.	0.1	1.4	3.0	45.0	Somewhat colored, fuzzy around the edges.
52.	1.0	1.4	3.0	45.0	No treeing, no stria, good throwing power, shiny.
53.	0.1	1.4	4.0	45.0	Treeing, good throwing power, shiny.
54.	1.0	1.4	4.0	45.0	Very slightly rough on corners, otherwise same as (52).
55.	0.1	1.4	8.0	45.0	Extensive treeing, otherwise same as (53).
56.	1.0	1.4	8.0	45.0	A few very short trees on corners, very good throwing power, shiny.
57.	0.01	1.4	2.0	0.0	Treeing and fuzzy on edges.
58.	0.1	1.4	2.0	0.0	Definite stria, bluish color, only very short trees on corners.
59.	1.0	1.4	2.0	0.0	No trees, no stria, bluish color, slight cracking on bending.
60.	10.0	1.4	2.0	0.0	Shiny, no trees, no stria.
61.	0.1	1.05	2.0	0.0	Striated, short trees on corners.
62.	1.0	1.05	2.0	0.0	No trees, no stria.
63.	0.1	0.7	2.0	0.0	Striated, treeing on corners.
64.	1.0	0.7	2.0	0.0	Bluish color, short trees on corners, no stria.
65.	0.1	0.35	2.0	0.0	Dark color, slight striation.
66.	1.0	0.35	2.0	0.0	No stria but short flat trees on corners and fuzziness on edges.
67.	0.01	1.4	4.0	0.0	Slightly rough, fairly long trees, no stria.
68.	0.1	1.4	4.0	0.0	Very slight striations, long trees, smaller crystal size.
69.	1.0	1.4	4.0	0.0	Smoother than (59) and better adherence; white in color.
70.	10.0	1.4	4.0	0.0	Some treeing, shiny and smooth.
71.	0.1	1.05	4.0	0.0	Extensive treeing, bluish color.
72.	1.0	1.05	4.0	0.0	Two short trees, otherwise same as (69).

Ref. No.	Con. of Wetting Agent (%)	Molality $Pb(NO_3)_2$ solution	Current Density (Amps./dm^2)	Temperature (°C)	Notes on Deposits
73.	0.1	0.7	4.0	0.0	Slight striation, extensive treeing.
74.	1.0	0.7	4.0	0.0	Same as (72).
75.	0.1	0.35	4.0	0.0	Slight stria, black around edges, treeing.
76.	1.0	0.35	4.0	0.0	Same as (75) but less treeing.

Discussion—Ultrawet

This wetting agent gave the best deposit of any of the 118 wetting agents tried. In 1.4 molal lead nitrate solution and at 30° and a current density of 2 amps./dm^2 (with a concentration of the wetting agent 0.1% by weight) the bath gave a fine even deposit of good adherency which did not crack on bending and exhibited only a few short trees on the corners.

The solution containing 1% by weight of Ultrawet under the same conditions gave an even finer and brighter deposit with good throwing power. The best deposits of this group were obtained at 45°C. Decreasing the temperature to 0°C decreased the adherency of the deposit; decreasing the concentration of the lead nitrate and decreasing the temperature increased the tendency toward striated deposits. No striated deposits were obtained at 45°.

Other trials made but not listed in the data included stirring several of the baths, a procedure which produced no improvement in the deposit nor lessening of treeing.

Deposition of lead from these baths was also carried out on copper, brass, and iron cathodes with a solution containing 1% by weight of the wetting agent in 1.4 molal lead nitrate at 30° C. They were all even, smooth deposits of good color, the deposit on copper being the smoothest.

A perchlorate bath was prepared as directed by Blum and Hogaboom[8] (page 340) for purposes of comparison. All of the better deposits of Ultrawet compared favorably with the deposits obtained from the perchlorate bath under the same conditions. A fluoborate bath, as described by Gray and Blum,[9] was also prepared using directions for the bath at higher current densities. The deposit obtained from this bath was compared with the deposits obtained from the 1% Ultrawet solution at 30°. If deposition was carried out at 2 amps./dm^2 for an hour or less the deposits compared very favorably. In deposits run under these conditions for six hours and fifteen minutes the fluoborate bath was superior to the Ultrawet as the Ultrawet deposit had a tendency to form short burrs on the edges. The mass of the lead deposited in this comparison was approximately 4.5 grams on a cathode surface of 6.25 cm^2.

Summary

Electrodeposition of lead from lead nitrate solutions in the presence of 118 wetting agents has been studied and the characters of the deposits recorded. The mass of the deposits was determined on 30 of these cases. The most important points for each group have already been discussed. In general, approximately 25% of the deposits were slightly finer than the control. The two outstanding deposits were obtained in the presence of Nekal AEMA and Ultrawet.

Most of the wetting agents tried gave precipitates or were insoluble to the extent of 0.1% by weight. Those that were soluble and gave no precipitate were: Alkanol S, Aerosol 1B, Aerosol AY, Betasol OT, Emulphor ELA, Triton NE, Tween 20, and Tween 80. None of the deposits from this group of wetting agents were outstanding. The group which showed the most variation in deposit types was the sulfonates, which contained both the poorest and the best deposits.

It is interesting to compare the results of this study with those of Taft and Hiebert[7] in their work with silver. They found that almost all of the wetting agents tried had some effect on form of the deposit. With lead, however, not more than 60% of the wetting agents tried gave deposits appreciably different from the control. In comparison with the work of Taft and Finke[2] on lead deposition in the presence of a wide variety of types of addition agents, we find that wetting agents have more effect on the deposit than do addition agents which are not classified as wetting agents.

It may be concluded that operating conditions affect the form of the deposits here studied as follows: an increase in temperature decreases the tendency for the formation of striated deposits; increase of current density and a decrease of temperature causes a decrease in crystal size; usually, too, a more adherent deposit but with increased treeing is produced by increasing current density and decreasing temperature.

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Aging of Plant Tissue and Stress-Strain Curves, Modulus of Elasticity and Specific Gravity of Plant Tissues

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INTRODUCTION

In two recent papers the stress-strain curves of different elastic plant tissues were investigated, and some general laws were found. [10] The following experiments were undertaken to find further properties of these plant tissues. The new experiments were carried out at the Biological Station of the University of Michigan during July and August, 1944.

I wish to express my appreciation to Dr. A. H. Stockard, Director of the Station, for the use of laboratory facilities.

A. AGING OF PLANT TISSUE AND STRESS-STRAIN CURVES

I. *Method*

For constructing the stress-strain curves the same method and the same apparatus were used as in 1942 and 1943. [10] The measurements were improved by using a glass plate and runners at the bottom of the movable clamp. To eliminate the time effect, all elongations were measured after 3 minutes. [10] For stress-strain experiments with respect to aging of plant tissue rhizomes of *Equisetum fluviatile* were used.

Most of our elastic plant tissues investigated were very extensible and rubber-like, and like rubber they have small moduli of elasticity.[10] From physics it is known that steel is more elastic than rubber because the modulus of elasticity of steel is much greater than the modulus of elasticity of rubber. So we may say steel has a high elasticity, but rubber has small elasticity and high extensibility. Then our elastic and extensible plant tissues of small modulus of elasticity have high extensibility and small elasticity. Elastic plant tissue is extensible if a large strain is produced by a small stress. Now this definition is used instead of our old definition according to which extensible plant tissue is more elastic than steel. [10]

There might be the question whether our stress-strain curves

refer to elasticity of cell walls and protoplasm. We found that the extensible rhizomes of *Equisetum fluviatile* which were dried for several weeks are still easily stretched. So we may assume that in our experiments cell walls are responsible for the elasticity, and that the extensible protoplasm and other interior parts of the cells add little elasticity or no elasticity at all. This conclusion is checked by the remark of S. J. Record [8, p. 47] that "the strength is in the walls, not the cavities of wood". Besides, our observation of rhizomes of *Equisetum fluviatile* is further checked by another remark of Seifriz [9, p. 233]: "When an entire cell is stretched, it is the elasticity of the cell membrane that is determined".

II. *Stress-Strain Curves of Rhizomes of Equisetum fluviatile of Different Age*

In the paper "Elasticity of Plant Tissues" [10] it was stated that the physical part of growth might be explained by using stress. Therefore stress-strain experiments with rhizomes of *Equisetum fluviatile* of different age were undertaken. The elastic rhizomes of *Equisetum fluviatile* are very extensible and the parts of different age have different colors. So this plant material was very suitable for our experiments. The rhizomes were collected from the shore of Marl Bay on Douglas Lake, Mich. We used pieces of a rhizome of about 10 meters length. One end of this rhizome was very old, the other end was the youngest part of the rhizome.

In a first series of experiments we used four pieces of the rhizome. The youngest (first) piece had yellowish color, and the stress-strain curve was a parabola. [10] The next older (second) piece had light brown color, and the stress-strain curve was S-shaped [10] and steeper than the parabola. The next older (third) piece was brown, producing an S-shaped stress-strain curve which was still steeper. The oldest piece was dark brown, its S-shaped stress-strain curve was the steepest of the four curves. In addition, the four curves show that breaking stress increases with increasing age.

As we will see later these four curves of the first series describe physical conditions during youth and middle age.

In a second series of experiments we investigated more pieces of different age. The result of this series is given in Figure 1. The curves are passing through the points of observation or are not much adjusted. For getting a clearer figure some points of observation are omitted.

1. The stress-strain curves I and III for yellowish white young rhizome pieces are parabolas. These stress-strain curves prove that the plant material is fairly plastic; [10] it is the growing part of the rhizome. The modulus of elasticity, found from the curves I and III by dividing stress and strain at elastic limit, [10] is 3×10^8 dynes/cm^2. This means that young growing rhizomes of *Equisetum fluviatile* are very extensible. The breaking stress and breaking strain are very low. For curve I breaking stress is 1.1×10^7 dynes/cm^2, and breaking strain is 0.042. For curve III breaking stress is 3.9×10^7 dynes/cm^2 and breaking strain is 0.290. The very low values of curve I seem to indicate that the piece of rhizome used was in bad condition. Curve III probably is normal.

The curves I and III describe the physical conditions in the rhizome during youth. These conditions are plasticity, high extensibility because of low modulus of elasticity; other conditions are low breaking stress and low breaking strain. This juvenile yellowish-white rhizome contains the growing plant material.

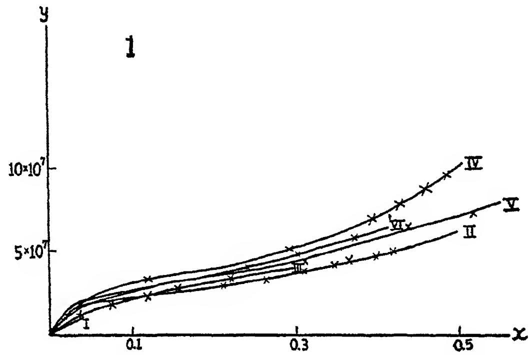
2. The stress-strain curve II for a yellow and older rhizome piece is an elastic S-curve [10] which in the beginning is steeper than parabolas I and III and whose modulus of elasticity is 4×10^8 dynes/cm^2. That means older rhizomes are less extensible but more elastic than young ones.

Probably there is no more growth at the rhizome of curve II. This assumption is checked because in the stress-strain experiments the rhizomes usually did not break at nodes. So we do not expect much soft meristem at nodes of older rhizomes. For curve II breaking stress is 6.0×10^7 dynes/cm^2 and breaking strain is 0.500.

The stress-strain curve IV for a light brown rhizome piece is an S-curve still steeper than curve II. The piece of rhizome is older than the last one of curve II. Modulus of elasticity is 4×10^8 dynes/cm^2. For curve IV, breaking stress is 10.2×10^7 dynes/cm^2 and breaking strain is 0.503.

The curves II and IV describe the physical conditions in the rhizome during middle age. These conditions are higher elasticity than in youth because of the higher modulus of elasticity, higher breaking stress and higher breaking strain than in youth. The middle age rhizomes do not grow any more. Breaking stress and breaking strain increase with age and the S-curves become steeper with increasing age. During the middle age the color of the rhizome turns from yellow to light brown.

3. The stress-strain curve V for a brown rhizome piece is an S-curve steeper than curves II and IV in the beginning, but becomes flatter than IV after the small strain 0.04 is passed. Modulus of elasticity is 4 x 10^8 dynes/cm^2. For curve V breaking stress is 8.0 x 10^7 dynes/cm^2 and breaking strain is 0.553. The brown rhizome V is older than the light brown rhizome IV.



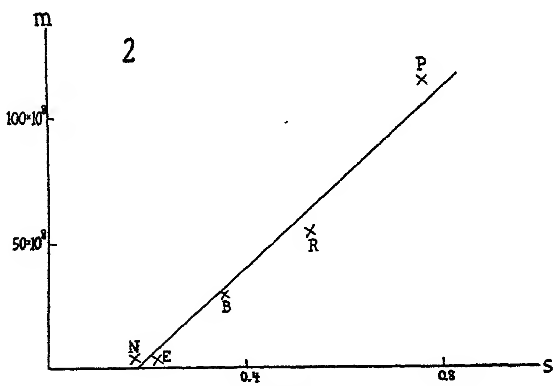


PLATE I

FIG. 1.—Stress-strain curves for rhizomes of Equisetum fluviatile of different ages.
x=strain, y=stress in dynes/cm^2.
Curves I and III refer to youth.
Curves II and IV refer to middle age.
Curves V and VI refer to old age.

FIG. 2.—Straight line relationship between specific gravity and modulus of elasticity for extensible and elastic plant tissues.
s=specific gravity, m=modulus of elasticity in dynes/cm^2.
E=rhizome of Equisetum fluviatile.
N=petiole of Nymphaea odorata (tuberosa).
B=stem of Brasenia schreberi.
R=woody root of Rhus glabra.
P=sclerenchymatous plate of rhizome of Pteris aquilina.

The stress-strain curve VI for a black brown rhizome piece is an S-curve flatter than curve V in the first part. Modulus of elasticity is 4×10^8 dymes/cm². For curve VI breaking stress is 6.4×10^7 dynes/cm², breaking strain is 0.415. The dark brown rhizome VI is older than the brown rhizome V.

The curves V and VI describe physical conditions in the rhizome during old age. The S-curves become flatter with increasing age, breaking stress and breaking strain are decreasing with increasing age. Rhizome V has still higher breaking strain than rhizome IV, but rhizome VI has a lower breaking strain than rhizome V. The plant material is deteriorating during old age. At this time the color of the rhizome turns from brown to black brown.

The rhizomes of middle age and old age are harder than the youthful rhizome because the value of modulus of elasticity 4×10^8 dynes/cm² is greater than 3×10^8 dynes/cm². (10) In fact, observation shows that the young growing rhizome is soft and that old rhizomes, which have stopped growing, are hard.

III. *Stress-Strain Relations for Vulcanized Rubber at Aging*

The process of vulcanization transforms rubber from the plastic state into the elastic condition. (5, p. 270) Stress-strain curves of elastic and extensible vulcanized rubber are to be compared with stress-strain curves of old rhizomes of *Equisetum fluviatile.* Both kinds of curves are S-shaped. (10) So we might expect that aging at rhizomes of *Equisetum fluviatile* takes place in a similar way as aging of vulcanized rubber.

All rubber goods have only a limited life, they age and gradually deteriorate, becoming hard and brittle. Oxidation of the rubber has long been recognized as the reason for this phenomenon. (5, pp 604, 605) The correctness of considering aging as an oxidation process is shown by the fact that vulcanized rubber can be kept almost indefinitely if air and light are excluded.

Stevens investigated the oxidation of different sorts of vulcanized rubber. He used a mixture which consisted of 90 parts of rubber and 10 parts of sulfur. Test pieces of this composition were vulcanized for 2 hours, 3 hours and other times at 134.5° C. These different test pieces were investigated for breaking stress and breaking strain after a definite period of storage in the dark at room temperature. This period of storage was the time of aging for the test pieces. Some results of Stevens follow:

Aging (days)	Breaking stress of test piece after 2 hours time of vulcanization grams/sqmm.
4	900
125	950
203	1010
311	920

For comparison we again tabulate the breaking stress numbers for rhizomes of *Equisetum fluviatile* of different age:

	Breaking stress dynes/cm².
Young yellowish white rhizome	3.9×10^7
Older yellow rhizome	6.0×10^7
Medium old light brown rhizome	10.2×10^7
Very old dark brown rhizome	6.4×10^7

These figures show that the breaking stress of the test piece of vulcanized rubber changes in a similar way as the breaking stress of rhizomes of *Equisetum fluviatile* when rubber and plant tissue become older. In the beginning the breaking stress is increasing; after aging the breaking stress is decreasing. Now oxygen is the active agent in the aging of rubber. So we may assume that oxygen plays an important part in the aging of rhizomes of *Equisetum fluviatile.* But the oxidation process for living plants is respiration. Hence we have to assume that aging of rhizomes of *Equisetum fluviatile* and the respiration process are closely connected.

IV. *Respiration and Aging of Plant Tissue*

It is well known that the intensity of respiration varies markedly with the age of plant tissue. [6, pp. 964–967] So the assumption in III is very probable that aging of *Equisetum fluviatile* rhizomes is closely connected with respiration. Much investigation about respiration and aging of plant tissue was done by Gustafson and Hover. [2, 3]

In 1926 Gustafson and Hover observed the respiratory activity of the leaves of different grasses. [3] They noted a decreased respiratory activity with increasing age until middle age and thereafter a gradual increase as determined per unit of dry weight.

If we compare their results with our results for rhizomes of *Equisetum fluviatile,* we have to assume that during youth the growing rhizomes have a decrease in respiration. During middle age there might be an increase of respiration. During middle age the rhizome has stopped growing, but it becomes stronger in its structure because of increasing breaking stress and breaking strain during this time. This explains the increase of respiration for *Equisetum fluviatile* rhizomes at middle age.

The experiments of Gustafson and Hover in 1926 did not give a definite result for respiration during old age. [3]

In 1929 Gustafson investigated the respiration of tomato fruits during time of growth and time of ripening. [2] He found that at the beginning of growth, green tomatoes have extensive respiration. As growth of these green fruits diminishes there is a decrease in respiration. At the time when the green fruits stop increasing in diameter the respiration reaches a minimum: during youth therefore, the respiration of growing tomato fruits is decreasing.

As the process of ripening progresses the respiration of tomato fruits increases. A maximum of respiration is reached at the time when the fruits become orange in color; during middle age, therefore, respiration of tomato fruits is increasing.

Now a decrease of respiration takes place until the fruits are ripe; during old age respiration of tomato fruits is decreasing.

Bergman [1] found that during ripening of blueberries, that is during middle age and old age for the fruit, the same changes of respiration were found as for tomato fruits by Gustafson.[2]

The experiments of Gustafson and Bergman [1 2] show that there are three different periods in plant life with respect to respiration. According to the leaf experiments of Gustafson [3] only two such periods occurred.

According to our experiments we have also three different periods in the life of *Equisetum fluviatile* rhizomes with respect to the strength of the rhizome. It has already been stated that *Equisetum fluviatile* rhizomes during youth and middle age probably behave like leaves of grasses and tomato fruits with respect to respiration. By comparison we might assume that during old age *Equisetum fluviatile* rhizomes have decreasing respiration. Corresponding to the decrease in respiration during old age it was found for *Equisetum fluviatile* rhizomes that breaking stress and breaking strain are decreasing. It is obvious that such deteriorating rhizomes do not show much life activity and so show decrease in respiration.

Respiration gives energy to the protoplasm of the cells. During the different life periods a different amount of energy is available for protoplasm. It might be assumed that corresponding to energy available for protoplasm, the protoplasm may act on the strength of the cell walls. Therefore it might be possible that during the life of a plant, difference in respiration is responsible for difference in the physical structure of cell walls.

B. Modulus of Elasticity and Specific Gravity of Plant Tissues

I. *Method*

The measurements for moduli of elasticity were made in 1942 and 1943. [10]

For measuring of specific gravity we have first to define specific gravity of plant tissue. It is for practical reasons that we define

$$\text{“Specific gravity”} = \frac{\text{weight of dry tissue}}{\text{volume of fresh tissue.}}$$

A similar definition is used for woods in the Forest Products Laboratory. [4, p. 81 and p. 99]*

The plant tissues investigated were rhizomes of *Equisetum fluviatile* and *Pteris aquilina,* stems of *Brasenia schreberi,* petioles of *Nymphaea* and roots of *Rhus glabra.* By using a vernier caliper we find the diameter $2r$ of such a tissue, for instance of a stem. By microscopic observation the area of the cross section of the stem is drawn on cross-ruled paper. Then by comparing solid material and cavities, for instance air chambers, the fraction k of solid material is easily found. We get for the cross section of the solid stem the value $k \cdot \pi \cdot r^2$. After measurement of length 1 of the stem the volume of fresh tissue $k \cdot \pi \cdot r^2 \cdot 1$ is computed.

Now the tissue is dried till no change of weight is to be observed during several days. The weight w is found by using a shell balance. At last we compute

$$\text{“spec. gravity”} = \frac{w}{k \cdot \pi \cdot r^2 \cdot 1}$$

The "spec. gravity" is an average value of several tissues observed, for instance of several stems observed of *Brasenia schreberi.*

II. *Mathematical Relation Between Modulus of Elasticity and Specific Gravity*

According to Price [7, p. 4] practically all wood cells are in the form of long hollow cylinders and by far the greater proportion of them are arranged parallel to the axis of the stem. We may assume that this is also correct for the rhizomes, roots, stems and petioles investigated. With stems of wood it will require less thrust to flatten the cells parallel to the axis diametrically than to compress them longitudinally. [7, p. 5] Hence there are two moduli of elasticity, E_L

*The formula used there is

$$\text{specific gravity } G = \frac{\text{weight in grams}}{\left(1 + \frac{\text{percent moisture}}{100}\right) \times \text{volume in cubic centimeters.}}$$

G is used as a pure number.

Because our definition refers to dry weight and to fresh volume the quantity is called "specific gravity."

for longitudinal direction and E_T for transverse direction. According to Price (7, p 9) it is

$$\frac{E_T}{E_L} = \frac{\pi h^2 (a+h)^2}{6 . (1-1/16) . 4a^4 \times 0.116}, \text{ where}$$

$2h$ = thickness of cell wall,
a = radius of middle surface passing through cell wall.

A conclusion from this equation is that

$E_L = k. s$, where
s = spec. gravity,
k = factor of proportionality.

The last equation is only approximately correct for stems of wood and by assumption for the tissues we used and for our definition of spec. gravity.

III. *Experimental Result for the Relation Between Modulus of Elasticity and Specific Gravity*

By experiments of Newlin and Wilson (4, p. 37) for different species of wood is

modulus of elasticity* = (2360 000 × spec. gravity) pounds per square inch. (based on measurements of green wood).

This result is checked by the theory (Part II).

Recent experiments of Wiepking and Doyle (11) show that different individual pieces of balsa and quipo woods have a straight line relationship between spec. gravity and modulus of elasticity. But these straight lines don't pass through the origin as the line of the experiments of Newlin and Wilson, but intersect the horizontal axis of spec. gravity to the right of the origin. For quipo the experiments give the equation

modulus of elasticity = (2,500,000 × spec. gr. — 150,000) pounds per square inch.

This result is also checked by the theory (Part II) because the theory only demands approximate proportionality of modulus of elasticity and spec. gravity.

Our investigated plant tissues were extensible and elastic. The following table gives our experimental results.

Plant Tissue	"Specific gravity" (values of 1944)	Modulus of elasticity dynes/cm². (values of 1942 & 1943)	"Spec. gr." adjusted by use of Fig. 2
Rhizome of *Equisetum fluviatile*	0.23	4×10^8	0.22
Petiole of *Nymphaea odorata (tuberosa)*	0.17	5×10^8	0.22
Stem of *Brasenia schreberi*	0.36	28.5×10^8	0.34
Woody root of *Rhus glabra*	0.53	54×10^8	0.48
Sclerenchymatous plate of rhizome of *Pteris aquilina*	0.76†	116×10^8	0.80

*In this paragraph the modulus of elasticity always is taken for longitudinal direction.
†The volume of the plate is length × width × thickness. This volume is used for computation of spec. gravity (see Part I).

Now "spec. gravity" and modulus of elasticity are considered as coordinates of points. So we get Fig. 2. The diagram shows that for extensible elastic plant tissue there is a similar linear relationship between specific gravity and modulus of elasticity as for balsa and quipo woods. The straight line of Fig. 2 was fitted by the method of least squares.

The straight line also intersects the horizonal axis to the right of the origin. For the plant tissues we used we have the experimental equation:

$$\text{modulus of elasticity} = (191 \times 10^{8} \times \text{“spec. grav.”} - 37 \times 10^{8})\ \text{dynes/cm}^2.$$

This result too is approximately checked by the theory (Part II). By using the straight line of Fig. 2 we get the adjusted values of spec. gravity in the last column of the table.

In the table the "spec. gravity" of the woody root of *Rhus glabra* is computed by an indirect method because it is difficult to dry these roots. The volume of the large vessels of the root is to be computed by using microscopic cross sections. In fresh roots these vessels are filled with water. Then the amount of water in the root is approximately known. By subtracting the weight of water from the weight of the fresh root we get a roughly approximated dry weight of the root. Then the "spec. gravity" is to be computed as in method I.

The adjusted value of "spec. gravity" for woody roots of *Rhus glabra* is 0.48. According to Markwardt and Wilson [4, table 1] the spec. gravity of *Rhus hirta* wood is 0.47 at 12% moisture content. So our result for "spec. gravity" of woody roots of *Rhus glabra* is well checked.*

By our measurements of 1943 [10] it was known that for extensible elastic plant tissues the modulus of elasticity increases if the hardness increases. By our recent measurements the modulus of elasticity is increasing if the "spec. gravity" is increasing.

Hence we may expect hardness of extensible elastic plant tissues to increase with specific gravity.

This result is checked by the experiments of Newlin and Wilson [4, p 37] who found that the hardness of wood is approximately proportional to the square of specific gravity. [8, p. 54]

Another consequence is found from Fig. 2. Young rhizomes of *Equisetum fluviatile* and petioles of *Nymphae tuberosa* have parabolic stress-strain curves. That means these tissues are nearly plastic.[10] The points of these two tissues with small modulus of elas-

*In the case of the woody root, dry tissue and fresh tissue have about the same volume.

ticity in Fig. 2 are near horizontal axis. So we might assume that extensible plant tissues of "specific gravity" less than 0.19 are only plastic and no more elastic. The extensible elastic plant tissues of "specific gravity" greater than 0.19 are the more elastic the greater the "specific gravity." This result is checked by the fact that rubber is plastic, but vulcanized rubber with the small modulus of elasticity 0.08×10^8 dynes/cm^2 is elastic.

Extensivle elastic plant tissues of small spec. gravity have little elasticity and great plasticity. Extensible elastic plant tissues of greater specific gravity have greater elasticity and little plasticity. Extensible elastic plant tissues exhibit both plasticity and elasticity. This result is checked by observations of elasticity of synthetic yarn [12].

Summary

1. During youth the rhizome of *Equisetum fluviatile* has a yellowish white color. Young rhizomes contain the growing plant material, they are quite plastic, have high extensibility, low breaking stress and low breaking strain. The stress-strain curves are parabolas.

2. During middle age the rhizome has a light brown color. These pieces of rhizome have higher elasticity, higher breaking stress and higher breaking strain than in youth. The stress-strain curves are S-curves.

3. During old age the rhizome has a dark brown color. The stress-strain curves are S-curves which become flatter with increasing age. Breaking stress and breaking strain are decreasing with increasing old age.

4. As vulcanized rubber is aged by oxidation, rhizomes of *Equisetum fluviatile* probably are aged by respiration. The stress-strain curves and changes of breaking stress are similar for both vulcanized rubber and rhizomes of *Equisetum fluviatile.*

5. By comparing with Gustafson's experiments on respiration and aging it is assumed that during youth plastic rhizomes of *Equisetum fluviatile* undergo a decrease in respiration. During middle age the rhizomes have increasing breaking stress and breaking strain which is probably connected with increasing respiration.

If during old age the rhizomes have decreasing breaking stress and breaking strain, they are deteriorating. This fact is probably connected with decreasing respiration.

During the life of plants respiration acts on protoplasm and

protoplasm acts on cell walls. Differences in respiration therefore during the life of the plant may cause differences in the physical structure of the cell walls.

6. By applying the mathematical theory of elasticity to wood, Price found that the modulus of elasticity of wood approximately is proportional to the specific gravity of wood. It is assumed that this relation is also correct for extensible elastic stems, petioles, rhizomes and roots.

7. For extensible elastic plant tissue there is a linear relationship between "specific gravity" and modulus of elasticity. The straight line intersects the horizontal axis of "specific gravity" to the right of the origin. This experimental result is checked by the theory of Price.

8. Hardness of extensible plant tissue increases with "specific gravity."

9. It might be assumed that extensible plant tissues of "specific gravity" less than 0.19 are only plastic and not elastic. The extensible elastic plant tissues have increasing modulus of elasticity with increasing "specific gravity" for values of "specific gravity" greater than 0.19. Extensible elastic plant tissues exhibit both plasticity and elasticity.

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Development of Adventitious Roots Inside the Trunks of Trees

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Sometime prior to 1924, a number of umbrella catalpa trees (*Catalpa bignonioides* var. *nana*) were set on the campus of the Kansas State Teachers College at Pittsburg, Kansas. During 1939, most of these trees were removed because of disease. The writer had an opportunity to examine some of the trunks in December of 1939. The trees were about 20 inches in diameter at breast height and the boles were about 6 or 7 feet long. Most of the trunks had been split lengthwise and many adventitious roots could be seen in the cavity formed by the decay of the interior of the trunk.

The much branched tops had collected trash, which had probably been holding much of the small amount of water which fell on them during the dry years. This may have served as a medium for decay fungi which penetrated the trunk to the base and also extended upward into some of the branches. No effort was made to determine the identity of the fungi but they were believed to be some of the common saprophytic forms.

The adventitious roots which grew down inside the trunk were straight and unbranched or with few branches. Most of the roots were small but some of them were one centimeter or more in diameter. None of them appeared to have been more than two or three years old. They had developed from the upper side of the scions, above the union of the graft. There was an average of about sixty of these roots per tree and they extended to a maximum length of about four feet.

In 1943, a large silver maple (*Acer saccharinum*) was cut on Brown Street in Liberty, Missouri. The heartwood was decayed, leaving a cavity about 24 inches in diameter. When the shell of the trunk was split open, adventitious roots up to about three centimeters in diameter were found growing down into the top of the trunk cavity from scar tissue around old broken snags of branches.

The catalpa is among the plants which are propagated by cuttings because of the ease with which they develop adventitious roots. No references were found in the literature to the phenomenon described here. It is our belief that these adventitious roots were formed in response to the water which was present in the decayed wood and in the debris collected in the crowns of the trees.

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Seasonal Food Choices of the Fox Squirrel in Western Kansas*

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Numerous references to food habits of the fox squirrel (*Sciurus niger rufiventer* Geoffroy) appear in the literature. This hardy species apparently utilizes a great variety of foods in different localities. Thus, Whitaker (1939) records the use of the seeds of Osage orange (*Maclura pomifera*) in eastern and central Kansas; Boulware (1941) found them feeding on the seeds of the eucalyptus tree in California; and Nichols (1927) list a number of interesting foods of the fox squirrel in and around Garden City, New York. Observation of the fox squirrels by the authors at Hays, Ellis County, Kansas, over a four year period (1939-1943), has uncovered some additional interesting food habits. The squirrels were observed, for the most part, on the campus of Fort Hays Kansas State College or in the immediate vicinity. Hays is located in the mixed-grass prairie region where stands of timber, suitable for fox squirrel habitation, are found only along stream banks or where artificial plantings have been made. The campus has a nice stand of endemic American elms, cottonwoods, and a few hackberries. Smaller numbers of non-endemic species are mixed in among the elms. In addition, Big Creek cuts across the southern end of the campus and along its banks occur cottonwoods, elms, hackberries, and occasional sycamores, among others. In the heart of the campus proper, there were at least four pairs of squirrels in residence.

The following list of foods is presented with brief notes on their utilization by squirrels.

Late summer and fall:

1. Hackberry nipple galls (*Pachysylla mamma* Riley). Before the leaves were completely stripped from the hackberry trees, (*Celtis occidentalis*), in October and early November, a squirrel would hold a leaf covered with nipple galls, (Fig. 1), in his paws and neatly slice off the solid top of the gall, without dis-

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*Contribution No. 52 from the Department of Zoology, Fort Hays Kansas State College, Hays, Kansas.

turbing the nymphs within. The nymphs were clustered in the basal hollow part of the gall. Many such topless galls were examined to make sure that the squirrels were not after the insects, but we never found one from which the nymphs had been extracted. Many times we stood below a hackberry tree in which a squirrel was perched and caught the leaves for examination as he discarded them after topping the galls.

FIG. I. (In Center) Hackberry nipple galls (Pachysylla mamma Riley). (Upper and lower center) Pods of the locust (Gleditsia triacanthos) from which seeds have been removed. (Upper right) Twig of cedar (Juniperus virginiana) from which berries have been devoured by fox squirrels. (Fall of 1943) (The photographs shown in Figs. I-IV were taken by Andrew Riegel.)

FIG. II. Russian olive trees (Elaeagnus angustifolia) from the branches of which bark had been removed by fox squirrels. Note lighter surface of branch just to the left of center of picture. (Fall of 1943.)

2. Cedar berries (*Juniperus virginiana*). Frequently in November and into December we watched fox squirrels cut off small terminal twigs loaded with cedar berries (Fig. 1) and devour the seeds before dropping the twigs to the ground. Although the seeds had been matured for some time, the squirrels resorted to them, according to our records, in the late fall only.
3. Pods of the honey locust trees (*Gleditsia triacanthos*). Another food taken in the fall the pods of the locust trees (Fig. 1). Many pods from which the beans had been removed were found on the ground below the trees on which the pods were produced.
4. Walnuts (*Juglans nigra*). A few walnut trees on the campus

bore sparingly. The nuts were never secured by watchful campus employees because the squirrels took them even before they were ready to fall.

5. Bark of the Russian olive tree (*Elaeagnus angustifolia*). In addition to utilizing the fruits of the Russian olive, as stated below, the squirrels would strip the bark from the smaller branches (Fig. 2). In August, September, and again in December, several squirrels were observed in this activity. The squirrel would cut a small incision in the bark which gave it a hold. Then it would strip a thin section of bark about one-half inch wide from the twig. Strips on the ground under the tree showed evidence of having been chewed (Fig. 3). Some of the bark strips may have been used also in constructing their nests.

6. Seeds of the wild gourd (*Cucurbita foetidissima*). A squirrel collects the ball-shaped fruits which are about the size of small apples and have smooth hard rinds. If the fruit is too large for the squirrel to carry in its mouth, he presses the fruit against the ground, sinks his incisors into the hard rind and carries it to a convenient perch in a nearby tree. The fruit is opened and the seed extracted. The rind and dry, pulpy interior are discarded. Small piles

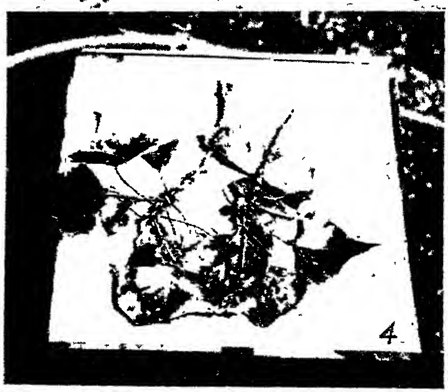

FIG. III. Strips of bark removed by fox squirrels on the ground below a Russian olive tree. Scats among the debris indicate the use of the bark strips as food by cottontails. (Dec. 22, 1943.)

FIG. IV. Petiole galls on cottonwood caused by a plant-louse. (Pemphigus sp.). The top of the one on the left has been eaten by a fox squirrel. (Summer of 1944.)

of this residue were found under favorite perches.

Summer:

1. Petiole galls on cottonwood (*Populus deltoides* or *P. sargentii*). In June and July, a petiole gall, caused by a plant louse (*Pemphigus* sp.) was often used as food (Fig. 4). In contrast to the hackberry galls, there was convincing evidence that, in many cases, the gall-makers were used as food. About half of one side of the petiole gall was cut off and eaten in addition to the gall-makers. Small twigs bearing two to four leaves would litter the ground under the trees.
2. Hackberry seeds. In late June grass seeds were used by the squirrels. The hulls of the little hard seeds cluttered the campus walks under the trees. They continued to use them through July.

Winter and Spring:

1. Elm seeds and buds (*Ulmus americana*). From February through March, buds and seeds of the American elm were utilized. Bunches of detached seeds were found under trees frequented by squirrels. The seeds were always extracted from the surrounding tissue by a small crescent-shaped incision.
2. Exudation on the branches of the walnut. In March, on numerous occasions, a squirrel was observed licking the base of a branch on a walnut tree. On closer observation the base appeared wet. The days were unseasonably warm and had followed a freezing period of several days. The spot was so high in the tree that it could not be determined whether there was an injury to the bark. Apparently the liquid was sap oozing through the bark and spreading over the nearby surface. Flickers, waxwings, and robins also visited the same tree and ate the secretions.
3. Fruits of the Russian olive. A few Russian olive trees were scattered about the campus. In March, the squirrels stripped the trees of fruits. They would cut off the terminal twigs loaded with fruits and after eating several of them, drop the twigs to the ground.

Miscellaneous Observations:

1. Mr. J. G. Harrison, forest nurseryman at the Fort Hays Experiment Station, told one of the authors that he has had great difficulty with squirrels from a near-by park digging up newly planted seeds, particularly those of nut trees. The squirrels would come across 150 to 200 yards of open ground and unerringly find the nuts and seeds. Unless frightened away, they seriously depleted the stands of seedlings.

    This experiment seems to suggest that the squirrels sense of smell played the chief role in locating the nuts and seeds. Certainly memory was not a factor as the squirrels did not bury the nuts themselves. Sight may have played some part but the actual discovery of individual nuts would seem to have been through the sense of smell.

The only noticeable damage on the campus that resulted from the feeding habits, noted above, was in the case of the Russian olive trees. The branches stripped of the bark died and appeared to weaken the whole tree. By the summer of 1944, however, the trees seemed to have recovered and showed no serious symptoms from their experience.

The effect of pruning by squirrels on the cottonwoods, cedars and hackberries is hard to evaluate but, as it has probably been going on for many years, and the trees are still healthy, it may even be beneficial.

The loss of viable seeds in the case of the elms is also probably negligible as many bunches survive on each tree and not all the seeds in a bunch are eaten.

This short list is enough to show that the fox squirrel is able to utilize a variety of materials for food in an area where oaks are absent and nut-bearing trees in general are scarce or non-existent. It is able to thrive on a somewhat different diet than is found farther east.

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A Mutant Red-Phase Wood Salamander (Plethodon cinereus) From New Hampshire

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This is a report on several series of amphibians and reptiles, received from New Hampshire during the spring of 1945. The most interesting of these specimens were eight wood salamanders from Andover, Merrimack County: seven of the common red-backed phase described by Bishop (1943, *Handbook of Salamanders,* p. 234), none of the lead-backed or dark phase, and one of a new all red phase not mentioned by Bishop. The red mutant was typical of *Plethodon cinereus* in every way, except for lack of dark pigment on the sides and below. It was uniform light red from the lower flanks upward and light below. The collector of this specimen was Miss Katherine Gulick, who also sent from the Andover area: *Desmognathus fuscus fuscus,* dusky salamander; *Eurycea bislineata bislineata,* two-lined salamander; *Triturus viridescens viridescens,* eastern newt; *Hyla crucifer,* spring peeper; *Rana palustris,* pickerel frog; and *Chrysemys picta picta,* eastern painted terrapin.

Additional New Hampshire records from 1945 collecting: young *Hyla crucifer* taken at Raymond, Rockingham County, by Robert A. Hellman; water stage *Triturus viridescens viridescens* found at Meredith, Belknap County, by Peter Lunt and the red eft land stage at Webster Lake in Merrimack County by Irene Wilson; and the milk snake *Lampropeltis triangulum triangulum* secured at Andover, Merrimack County, by Winslow Trueblood.

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Shoot Root Ratio and Moisture Relations

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Many shoot-root ratio studies have been made by various plant physiologists and ecologists. The data and conclusions of these workers do not always agree. Some of the workers [2] believe the ratio to be an hereditory factor while others [1, 5] believe it may be modified materially by environmental factors. Gier [3] noted a variation in this ratio in a study of tobacco plants as a result of competition, of cultural practices, of disease, or of the study of too few plants to be of statistical significance. He later [4] suggested that a relation may exist between shoot-root ratio and the following factors: soil profile; physical characteristics of the soil; aeration; and soil moisture content.

This paper gives the results of a series of experiments to determine the relation existing between the shoot-root ratio in tobacco and tomato plants and one environmental factor, the soil moisture content. Part of this study was financed by a research grant from the Kansas Academy of Science for which we are grateful. In the past five years, during which these experiments were in progress, various techniques were employed but these may be included in two major methods. In the first, the plants were grown in metal containers or clay pots filled with greenhouse potting soil or soil from a tobacco field. The soil was oven-dried then adjusted to three definite moisture contents, one with an excess, one with a deficiency and the third with an approximately optimum, supply of water. The moisture content was kept constant by repeated weighings. (The increase in weight of the plant was so small in proportion to the total weight that it was practically negligible). Four to six weeks after the plants had become established, they were cut, the roots washed from the soil, and the shoots and roots were dried separately for statistical studies.

With the second method, two wooden tubs were used. One was filled with washed sand and the other with water. Vigoro was added to each and the sand moistened to make about the same mineral concentration in each tub. A layer of cheesecloth was stretched

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across each tub and seeds sowed directly on the cloth. The water level was kept constant in the one and water was added to the other as needed to prevent wilting of the plants after they were established. Vigoro was added at two week intervals to the sand culture to maintain nearly the same mineral concentration during the experiment.

All data were analyzed for variance and covariance and the coefficients of correlation were computed for the weights of the shoots and roots of each lot. All analyses showed significance. The summarized data are shown in the table.

TABLE SHOWING SHOOT ROOT RATIOS

		Available Water			Shoot/Root Ratio		
Year	Crop	Hydric	Mesic	Xeric	Hydric	Mesic	Xeric
1940	Tobacco	16	8	4%	2.15	3.77	1.625:1
1942	Tobacco	20	10	3	8.56	8.64	8.76
1944	Tobacco	30	16	4	7.0	9.0	12.0
1944	Tomato	30	16	4	5.49	4.61	5.24
1945	Tomato	100*	—	2**	5.3		10.15:1

*—In water culture. **—In sand, 2% was maximum supply.

Bright Belt tobacco plants were grown in the north window of the laboratory in 1940. In 1942, Burley tobacco was grown in the east windows as were the tobacco plants in 1944. The Stone tomato plants were grown in the greenhouse in 1944 and in 1945 in the south windows of the laboratory.

The Burley tobacco in 1942 gave the lowest degree of significance in variance and covariance but the coefficient of correlation was high for each of the three groups. The xeric plants used 27 grams of water per plant per day while the mesic and hydric used 56 and 63 grams, respectively.

The Stone tomatoes in 1944 gave data which were not quite comparable to the others. It is suspected the attendants in the greenhouse preferred to disobey rather than see the plants wilt each day. The hydric plants used large quantities of water so the moisture average of 30 per cent did not prevail, this being the maximum rather than mean content. At the conclusion of the experiment this year (April 5) the plants were smaller than those of preceding years. The tops were about the same size in the two groups but there was a decided difference in the roots. The hydric plants had extensive root systems with many branches of the third and fourth order while the xeric plants were seldom branched and never more than once.

The tobacco plants of 1942 may be considered representative

of the three groups each year. These plants are shown in Fig. 1. Each plant had from 9 to 12 leaves, there being no relation between the number of leaves and the moisture conditions. There was much

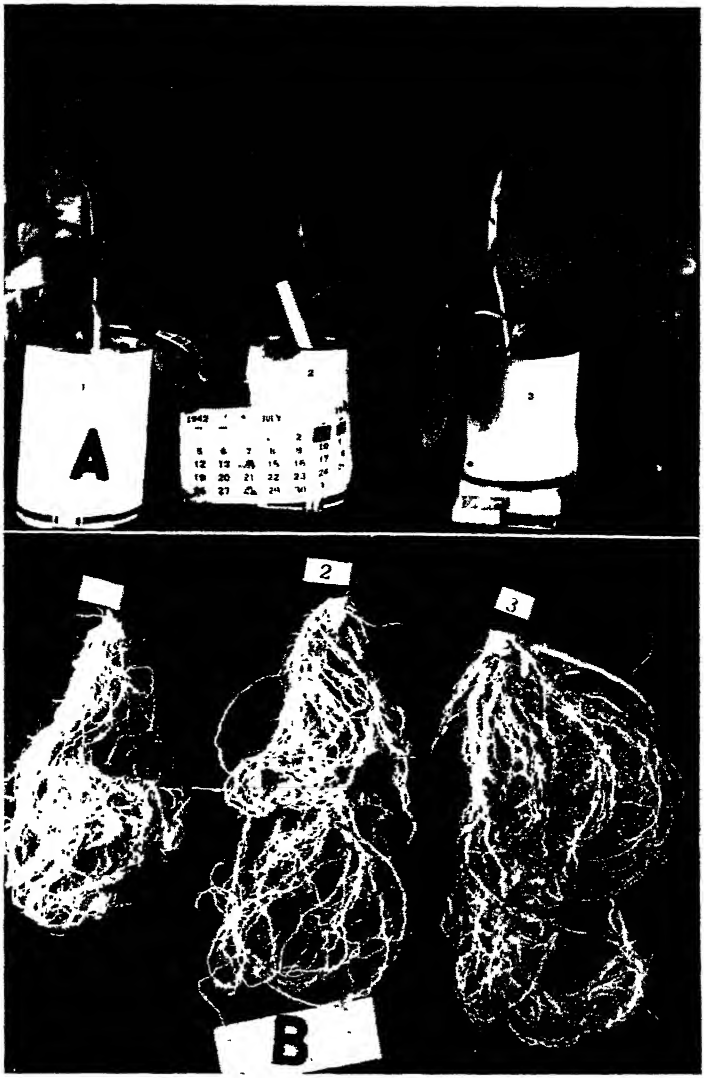

PLATE I

A.—Tobacco plants grown under three conditions of soil moisture.
B.—Root systems of same three plants.

1. Xeric
2. Mesic
3. Hydric

difference in the size of leaves in the three groups, the largest leaves being in the hydric group, but there was little difference in leaf weights between the groups. The root masses of these three plants may be seen in Figure 2; No. 1 being the xeric plant. The hydric roots (No. 3) were much softer so the dry weight was about the same.

The fact that the dry weight of leaves of tobacco was about the same regardless of moisture conditions is in agreement with a statement by Kramer, [6] "They have reported results of experiments indicating that the growth and quality" of various crops "were not affected by the moisture content of the soil unless it fell to the wilting percentage and remained there for days."

Turner [7] concluded that neither dry weight nor length of roots is a safe measure of growth in plants. In an earlier study,[3] we found a ratio of 4.95:1 for "normal" tobacco plants in the field while the average ratio for all plants studied was 10.02:1. Crist and Stout [2] demonstrated "a persistent positive correlation in size of top and root, regardless of the wide variations shown under special conditions."

In this study we have found variations existing in the ratios of shoots and roots, even under controlled conditions, for each of the two kinds of plants. From this, we conclude heredity is only one side of the problem of root and shoot growth and the environment may modify the growth pattern to a greater degree for one kind of plant than the variations expressed by heredity in two different groups.

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Phosphate Fixation by Soil Minerals IV
General

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The literature on phosphate fixation is voluminous. Among the many papers reviewing the field may be mentioned those of Gaarder Torbiorn [9] and Midgley [16]. Perkins and King [19-20] recently published two papers dealing particularly with phosphate fixation by mica and related groups of minerals and by some of the oxides. The present paper is an extension of the review and a revision of the discussion and data presented in those two papers.

Phosphate fixation in soils may be divided into fixation by organic and inorganic material. Fixation by organic matter could be studied according to the individual organic soil constituents as well as the effect of living micro-organisms on the assimilation and immobilization of phosphate. Fixation by inorganic matter may be subdivided into fixation by silicate and non-silicate minerals. Fixation by silicate minerals can be broken down into fixation by minerals of the various groups such as pyroxene, amphibole, felspars, etc., and the individual minerals can then be studied individually.

Fixation of phosphate by minerals undoubtedly is the result of several forces, including precipitation and physiochemical adsorption. Apparently phosphate fixation in soils is at first the result of a rapid reaction since almost without exception when soluble phosphates are added to the surface of a soil penetration to the deeper layers is quite slow. However, when phosphate stands in contact with a soil for a long time a second type of fixation sets in, since citrate soluble phosphate decreases with time. Beater [3] has shown that phosphate fixation is progressive, as it takes about a year for super-phosphate to become completely citrate insoluble in soil. Scarseth and Tidmore [25] also found that phosphate fixation by clay soils increase with time. Black [4] has shown for kaolin that 10 minutes to 48 hours mixing of kaolin with phosphate has little effect on its fixation, but that 2 months mixing greatly increases fixation. Stout [26] showed that phosphate may enter the crystal

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*Contribution of the Department of Chemistry, Number 300.

replacing OH ions. This might take appreciable time and would be in agreement with the above references.

In the literature several methods of studying phosphate fixation have been outlined, differing not only in technic but in results produced and information obtained. Among the methods which yield somewhat different results might be listed that of Bear and Toth (2) who filtered off the phosphate and washed excess phosphate out of the soil with water. This method includes the precipitated and strongly absorbed phosphorus and, for an equal time of mixing, will give lower fixation figures than the method used by Perkins and King (19). Heck (12) proposed boiling a sample to dryness with added phosphate. This would be a more violent reaction and would increase the penetration of phosphate into the soil particle and thus increase fixation. Morgan (17) suggests extracting the soil with a sodium acetate acetic acid mixture to determine available nutrients including phosphates. Dean and Rubins (7) suggest determining available phosphates by an anion exchange reaction with arsenic. The method of studying phosphate fixation used by Perkins and King measures the amount of phosphate attracted by the soil and held by the soil particles. Since by this method the time of shaking is 16 hours at room temperature (25° C), any fixation that takes a longer time or that involves a more violent reaction is not measured. Even though a part of the phosphorus carried down with the soil particles in the centrifuge may be so weakly held that it could be washed out by water it is measured as fixed.

That the mechanics of phosphate fixation and the forces involved are not well understood is evident from the literature on the subject. Metzger (15) believes that precipitation accounts largely for phosphate fixation and that adsorption, at least in certain soils, is of small significance. Ford (8) and Heck (11) indicate their belief in chemical precipitation. Chandler (6) states that in the clay portions of a soil phosphate adsorption is due to free Al_2O_3 and Fe_2O_3. A number of workers have indicated a belief in the amphoteric nature of soils and the importance of anionic adsorption in phosphate fixation. A few of the many among these are Mattson (14) who showed that adsorption of anions increased with decrease SiO_2/R_2O_3 ratio; Stout (26) who presented data to show an exchange of phosphate ion and OH ions; Scarseth (21) who reported that phosphate fixing capacity varied inversely with SiO_2/R_2O_3 ratio; Toth (27) who showed that the phosphate ion might be displaced either by adjusting the

pH or by adding sulfate ions, etc.; and Bear and Toth [2] who recognized both chemical precipitation and physiochemical adsorption. It may thus be concluded that the mechanism of phosphate fixation in soils is multiple in character.

In previously reported studies of phosphate fixation in variously treated soils some apparently contradictory data were obtained from the Kansas, Ohio, and New Jersey experimental plots, after 25 years of liming, yielded inconsistent results as to the effect of lime on the development of phosphate fixation [19]. To simplify the problem the effect of lime on the development of phosphate fixation in a single soil was studied, and when it was separated into its various components as sand, silt, and clay, it was found that lime had opposite effects on the development of phosphate fixation of the sand and clay [21].

Large crystals of the various minerals were selected for their original purity and then picked over by hand and electro magnet when it was possible to increase their purity. These were ground in a mullite mortar or a porcelain ball mill with frequent sifting to avoid excessive grinding until they would pass a 100-mesh sieve, making the largest particles about 150 microns in diameter. In every case the implement used to grind the mineral was harder than the mineral ground. A microscope examination indicated that the several minerals were ground to approximately the same average size, though the muscovite sample contained both the largest and smallest particles measured. That the degree of fineness of the mineral specie will have a great effect on the amount of phosphate fixed seems self-evident and has been determined by Murphy [18] who found that grinding kaolinite greatly increased its phosphate fixing ability and reported a high figure for the amount of phosphate fixed by ball milled kaolin. Raychaudhuri and Mukheyee [24] state that kaolin has little phosphate fixing ability but they probably refer to the coarse kaolin.

Perkins, Wagoner and King [22] reported that the finer separates of a Wabash soil fixed about six times as much phosphate as the coarser separates. However, in this case the minerals are decidedly different as shown by chemical analysis. Bear and Toth [2] found that the finer textured soils, such as silts, fixed more phosphate than sandy soils, fixation with loams being intermediate. This difference in phosphate fixation was probably due in part to different sized particles and in part to different mineral species. Petukhov [23] found

that sandy podzols have more acid soluble P_2O_5 than heavier podzols and that solentz formation increases P_2O_5 mobility. We may thus conclude that phosphate fixation is partly due to particle size and partly due to mineral species.

Preliminary work dealing with a large group of minerals including oxides, carbonates, fluorides, etc., among the non silicates and pyroxenes, amphibols, felspars, orthosilicates, etc., among the silicates indicated a large amount of work was needed. We focused our attention on a small number of minerals structurally related, as our data showed that members of this group were active in fixing phosphates.

The minerals reported in paper I are pyrophyllite and talc; muscovite, phlogophite and biotite of the mica group; margarite of the clintonite group; and kaolinite of the kaolinite group. From the detailed structure and idealized formulae given by Bragg, page 203 [5], the similarity among these minerals becomes obvious. Bragg's formulae divided into four categories are:

Kaolinite Group

Kaolinite .... $Al_4(Si_4O_{10})\ (OH)_8$

Pyrophylite .... $Al_2(Si_4O_{10})\ (OH)_2$
Talc .... $Mg_3(Si_4O_{10})\ (OH)_2$

Mica Group

Muscovite .... $KAl_2(AlSi_3O_{10})\ (OH)_2$
Phlogophite .... $KMg_3(AlSi_3O_{10})\ (OH)_2$
Biotite .... $K(Mg,Fe)_3(AlSi_3O_{10})\ (OH)_2$

Clintonite Group

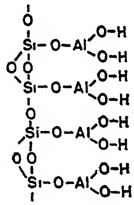
Margarite .... $Ca\ Al_2(Al_2Si_2O_{10})\ (OH)_2$

These are the simplest formulae showing the atomic ratios in the minerals and should be considered as the building blocks from which the more complex mineral is constructed.

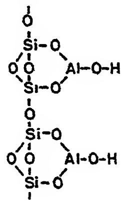
Quoting Bragg [5]: "in the above formulae, the groups (Si_4O_{10}), $(AlSi_3O_{10})$, or $(Al_2Si_2O_{10})$ represent the contribution of the linked sheets of tetrahedra . . . where silicon may be partially replaced by aluminum." The aluminum which has replaced silicon in the sheets may be defined as structural aluminum or anionic $Al\ O_3$—and the aluminum or magnesium which appears outside of this group as combined aluminum or magnesium (cationic Al^{+++} or Mg^{++}). In the above formulae the magnesium or ferrous iron in biotite is in the latter category.

With these definitions in mind it is seen that the above four groups of minerals, with the exception of biotite, are the aluminum or magnesium salts of (Si_4O_{10}), $(Al\ Si_3\ O_{10})$ or $(Al_2Si_2\ O_{10})$. Simplified, idealized structural formulae would be:

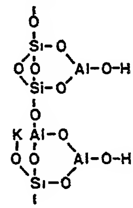
Kaolin



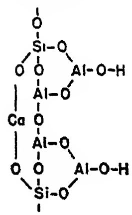
Pyrophyllite



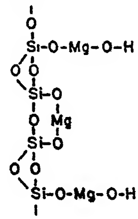
Muscovite



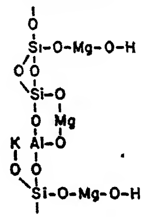
Margarite



Talc



Phlogophite



In each case according to Bragg [5], Hendricks [12], Grim [9], etc., the above silicon chain (or silicon and aluminum chain) should be regarded as a part of a hexagon ring with the hexagon rings interlocking to form sheets. The simplest formulae reduce to Si_4O_{10} or equivalent and the valencies which, according to Bragg, etc., would be joined to complete the hexagon rings have been extended unattached.

In the case of the micas where two sheets are bound together, half of the aluminum, etc., ions of the two sheets have been shown and the valences arranged to compensate. For a description of a concept of the linkage, the reader is referred to Bragg [5]. From the formulae given it can be seen that with kaolin as a pattern, pyrophyllite as an aluminum salt might be considered to be a mono-hydroxy, di-silicate compound rather than a di-hydroxy, mono-silicate. The relationship between pyrophyllite and muscovite is that one structural silicon atom of pyrophyllite has been replaced by an aluminum atom in muscovite, the extra valence being satisfied by a potassium atom. In margarite two of the structural silicon atoms of pyrophyllite have been replaced by structural aluminums

and the extra valences satisfied by a calcium atom. Talc is like pyrophyllite except that it is a magnesium rather than an aluminum compound and phylogophite bears the same relationship to muscovite in that magnesium has replaced the combined aluminum. In biotite some ferrous iron has replaced part of the magnesium in phlogophite.

The minerals reported in paper II [20] are hematite, limonite, magnetite, rutil, ilmenite and quartz. This group of minerals are all oxides and are closely related to each other. Idealized formulae: hematite, Fe_20_3; limonite, $2Fe20_3 \cdot 3H_20$; magnetite, Fe_30_4; rutil, $Ti0_2$; ilmenite, $Fe0 \cdot Ti0_2$; quartz, $Si0_2$.

According to Bragg [5] to whom the reader is referred to a more comprehensive discussion of the structure of these materials they form a series of tetrahedra and octohedra.

Methods

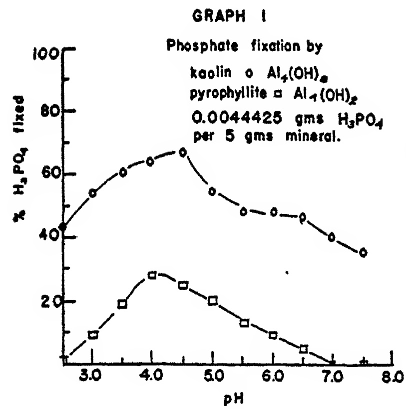
The method chosen to measure phosphate fixation is simple and indicates the amount of phosphate held by the soil immediately, either chemically precipitated or adsorbed and held by secondary or residual valences in the atmospheric around the particle. Five gram portions of the 100 mesh mineral were weighed into 100 ml. centrifuge tubes; sufficient water to bring the final volume to 25 ml., the amount of hydrochloric acid or sodium hydroxide required to adjust to the desired pH value, the indicated amount of phosphoric acid as H_3PO_4 were added successively. The mixture was rotated in an end over end shaker for about 16 hours in a constant temperature room (25°) after which the material was centrifuged to clarify the supernatant liquid. That the concentration of H ions, phosphate ions, etc., is considerably different in the supernatant liquid and in the centrifugal packed mineral is evidenced by the fact that it is only with many washings that wash water will be free from the phosphate ion.

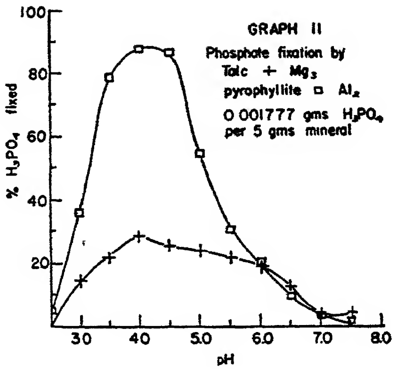
The phosphate in solution was determined by the molybdate method of Deniges as refined by Atkins [1] and the pH values by means of a quinhydrone electrode.

The detailed phosphate fixation data have been tabulated in the two previous papers [19] [20] and are briefly reviewed in graphs I to V.

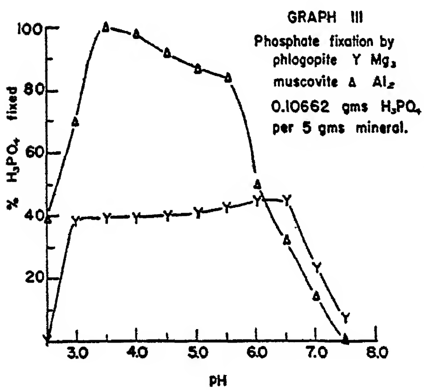
Discussion

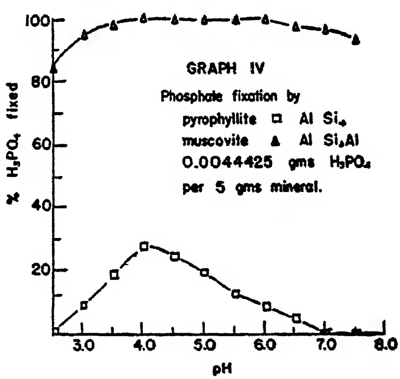
When the phosphate fixing capacities of Kaoline and pyrophlite are compared, kaolin is bound to fix more phosphate than pyrophlite,





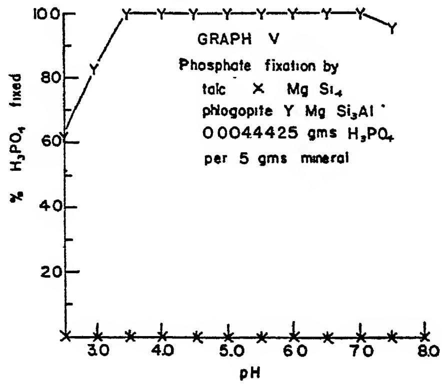
graph I. This has been attributed by Stout [26] and others to the increased number of OH ions in the molecule. It might also be attributed to the increased number of aluminum ions but is probably a combination of the two factors. When the magnesium minerals are compared to the corresponding aluminum minerals, i.e., talc with pyrophylite, graph II, and phlogopite with muscovite, graph III, it is seen that the magnesium minerals fix less phosphate than the aluminum minerals. It may be also noted that pH values at





which maximum fixation occurs is higher for the magnesium minerals than for the aluminum minerals and that at pH 6.5—7.0 the magnesium minerals rise above the aluminum minerals in fixing phosphate. This is in accord with results of Gaarder [9] and others and indicates that the combined magnesium and aluminum can play a role in phosphate fixation. It may also be noted that the minerals which have structural silicon replaced by aluminum have a much

higher phosphate fixing capacity, graph No. IV and V. Muscovite fixes more phosphate than pyrophylite and phlogophite much more than talc. Biotite, which is closely related to phlogophite, also fixes more phosphate than the corresponding mineral talc. In comparing biotite with phlogopite it is seen that when the magnesium is partially replaced by iron that phosphate fixation increases. However, fixation is not doubled in margarite where a double substitution of



aluminum for silicon has occurred. This might be due to the precipitation of insoluble calcium phosphate at the exposed edge of the crystal as a result of the substitution of calcium for potassium thus preventing penetration of the phosphate into the space lattice. Comparison of phosphate fixed with the SiO_2/R_2O_3 ratio reveals that muscovite, which has one of the lower SiO_2/total R_2O_3 ratios, stands at the top in phosphate fixation, while kaolinite which has the same SiO_2/total R_2O_3 ratio fixes only about 1/20 as much phosphate. An inverse ratio may be noted when SiO_2/structural R_2O_3 is compared with phosphate fixation and no relationship at all can be discerned when the SiO_2/combined R_2O_3 ratio is compared with fixation.

Phosphate fixation by the oxides presents some interesting data. The inertness of quartz is according with the accepted knowledge of this mineral. The small amount of phosphate fixed by magnetite and limonite indicate that the structure of the mixed oxides (ferrous and ferric ions and ferromium and titanium) is such that there is little or no place for the phosphate to become attached. The variation between the two varieties of hematite and limonite suggest that particle size as well as mineral structure may play an important part in phosphate fixation. As might be expected from the known inertness of quartz, it fixed practically no phosphate.

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The Use of a Battery of Psychological Tests for Diagnosis of Maladjustment in Young Children—A Case Report

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Introduction

During the last decade a significant change has taken place in the theory and practice of clinical psychology. Whereas previously psychological tests were devised and used primarily in order to ascertain either the intelligence quotient or the degree to which the person tested possessed a specific ability or aptitude, the present trend is to use psychological tests as a means of assessing in an integrated manner the functioning of the entire personality. This change in emphasis was a logical outcome of the more recent findings in regard to the nature of intelligence. Rather than considering intelligence a constitutionally determined unchanging trait we now view it as one of the functions of personality, variable with the specific characteristics of each individual, subject to stimulation and stunting, as well as to gradual disintegration where severe maladjustment is present.

With such a concept in mind a psychological examination tends, of necessity, towards the use of a variety of different tests in order to assess as many aspects of mental functioning as possible. Numerous psychological tests are available for the study of adult subjects, and a relatively clear picture has emerged of the nature and interdependence of various mental functions, so that diagnosis of mental illness by means of psychological testing has become possible. Where children, and especially young children, are concerned, the task lies still before us. In other words, specific test responses indicative of the presence of specific kinds of mental illness are lacking. Nevertheless, experience in the testing of both normal and maladjusted children suggests ways in which the combined results of various established testing procedures may yield an integrated view of the intellectual and the total personality functioning of a given child. In the following the results of such a testing procedure on one child are reported and a discussion of the meaning of these findings is offered.

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Case Material

Rose was a 6½-year-old child who was referred to the psychology department of the Menninger Clinic by a social agency prior to placement in a boarding home and school. Until her mother's death, not long before she was seen by us, she had lived with her own relatives. Except for a severe progressive myopia, her health was good. After a poor adjustment in one boarding home she had apparently adapted herself well to another one and was not considered a problem child.

Description of Test Results

The psychological examination procedures employed in her case were the following:

1. The Stanford-Binet Intelligence Test (Form L)
2. The Cornell-Coxe Performance Ability Scale
3. The Rorschach Test
4. The Thematic Apperception Test
5. The Drawing of a Man Test
6. A diagnostic play interview.

On the Stanford-Binet Test, with a chronological age of 6;6 years, Rose obtained a mental age rating of 6;4 years and a basal age rating of 4;6 years. This yields an I.Q. of 97, placing this child in the normal intelligence range. Although the total score is well within normal limits her test performance was in some ways atypical and reflected an impairment of mental functioning. For instance, she introduced irrelevant, and at times, absurd fantasy material into her test responses. When asked what was funny about the picture of a man walking in the rain and holding his open umbrella at his back rather than over his head (7;1) she said "Nothing is funny about it . . . his hand . . . he has got it cut off . . . sure, when the finger is cut off it hurts." When asked to repeat the sentence "Fred asked his father to take him to see the clowns in the circus" she said, "Fred lost his father."* She was barely able to copy a square and totally unable to approximate the shape of a diamond. These latter failures might be referrable to her visual handicap if it were not for the fact that other items requiring the same degree of visual acuity were passed, among these maze tracing (6;6) and mutilated pictures (6;3). In completing the picture of a man (5;1) she adorned

*There is of course nothing unusual in the failure of a 6-year-old to achieve an item on the 8-year level, but the content which Rose assigned to the sentence is significant in terms of her personal experience.

him with a gun and depicted the "smoke from shooting" by violent scribbles across the entire page.

On the Cornell-Coxe Performance Ability Test, Rose obtained a mental age rating of only 4; 6 years and an I.Q. of 69. If it were not for her much better performance on the Stanford-Binet this result would have been considered an indication of mental deficiency. Her visual handicap undoubtedly contributed in producing the poor result but for reasons enumerated above, and when viewed in the context of all test results, her failure cannot be explained on the basis of poor vision alone.

The Rorschach Test findings contained a number of important indications. (1) The quality of at least 10 of her 22 responses was sufficiently good to eliminate the diagnosis of mental deficiency. (2) The sharpness of some of her form perceptions again demonstrated that her visual handicap was not severe enough to account for failure on many performance items on other tests. (3) The presence of strong and poorly controlled aggressive impulses was indicated as well as the presence of marked anxiety. The degree of maladjustment indicated by numerous pathological responses was greater than the child's appearance and manner would have suggested. Among these pathological responses were frequent references to broken limbs and responses where she saw bombed trees and blood-spattered trees.

The Thematic Apperception Test, which consists of a series of pictures about which the subject is asked to tell a story, revealed much about Rose's attitudes and feelings. Her stories were more disorganized than is the case with most children of this age and the feeling-tone of the stories was one of gloom, anger, and pain throughout the series. With one exception each of the test stories contained the themes of destruction, anger, death and injury singly or in combination. No pleasurable experience was even referred to and all of the stories ended unhappily. Perceptual misrecognitions were present (as when female figures were seen as males, and vice versa). Two of her stories, which illustrate the violence and confusion which characterized her productions, as well as her childish hopelessness, are given below.

In response to a picture depicting a much magnified portion of a hand and thumb with a drop of liquid on the thumb she said "Oh, oh, that's a horse, he is mean. . . . Hey, that isn't a horse! That's a man!" (q. Where is the man?) "Here, that's the man's hand." (q. Where are his legs?) "His legs is down in the ditch. His arms is in the ditch too." (q. How did he get into

the ditch?) "He fell in the snow" (indicating white portion of picture). (q. How did he happen to fall?) "He got boots on him that 'slipses'." (q. What will happen?) "I don't know, he will fall down again (?) Yes, as soon as . . . he can't even get up 'cause as soon as he starts getting up he keeps slipping."

In response to a black and white drawing of two old men, one of whom appears to attack the other from the rear and both of whose faces look angry, Rose said, "Oh, it is Santa Claus climbing down the chimney. That isn't Santa Claus, it's Hitler. It's Hitler because Santa Claus isn't funny like that. They will get dead because their head is cut off." (q. Whose head is cut off?) "The American cut it off." (q. Where is the American?) "That one (pointing at lower figure) is the American. He cuts his head off, he is going to be put in jail for doing it. He always fights the other Hitlers and makes other Hitlers cry." (q. Who put him in jail?) "The policeman puts him in jail. No, that is a crook. The crook is going to kill him. No, it is a gorilla." (q. Who is this?—pointing at the lower figure). "That's a nice man, he is going home, he is out of the Army and he is going home to tell his mamma he is out of the Army. The gorilla won't let him and he is going to be killed. The gorilla is bad, he has got his fingers like this and he is going to choke him." (q. What happens to him?) "He won't get home."

The Drawing of a Man Test also revealed the way in which a realistic task situation became the vehicle for the expression of bizarre and unrealistic phantasies for this child. She drew a large circle which she called a head with what she designated as a "chimney growing out of the head," eyes in the usual position and four buttons down the center where the nose might be expected, and two small circles on the same side of the larger one designated by her as arms and ears respectively. A curlicue was attached immediately under the chin where the neck would ordinarily be and designated as legs. While she did not seem entirely satisfied with this production her earnest attempts to improve upon it on further trials resulted only in increasingly unstructured scribblings. This performance is so different from what is ordinarily encountered in drawings of children of this age as to be unscorable.

During the play interview, too lengthy to be here recorded in full, Rose showed an interesting oscillation between conventional and inhibited play on the one hand and peculiarly excited and infantile games which involved much banging and throwing of objects on the other hand. She was apprehensive when she saw broken toys even though she was reassured that they had been that way for a long time.

Evaluation of Test Results

When the results of all tests given are taken into account Rose presents herself as a child of average endowment who is unable to make full use of her capacities, due to the presence of severe emotional disturbances.

It may be well to point out in summary manner how the various test results contributed to such a diagnosis. The Stanford-Binet showed that on a sufficient number of items at least, Rose performed as well as do most children, although scrutiny of test responses revealed some impairment of functioning. This test alone would not have revealed the degree to which this child differs from the average in her capacity to deal with everyday situations. Results yielded by the Cornell-Coxe Performance Scale, taken by themselves, would have indicated a much more profound impairment of mental functioning than is actually present. The discrepancy between these two test results is of interest because normally the tests in question correlate highly. The explanation for the profound impairment of performance ability is to be found in the results of the diagnostic personality tests. The Rorschach Test confirms the Stanford-Binet results in that it eliminates the diagnostic possibility of a mental deficiency. The Rorschach Test also indicates the presence of severe maladjustment and the manner in which the child's overly intense and overly aggressive phantasies impose themselves upon conscious experience. The Thematic Apperception Test supplements the information gained so far by not only indicating the intensity of her phantasy life but also by giving definite clues as to the nature and direction of her phantasies. The attitudes and feelings Rose expressed on this test are of the type frequently seen in children who feel themselves deserted by their parents or parent figures and react with resentment and hostility toward such figures, and yet with a forlorn hope that they may return. The play interview added yet another bit of information not obtained from any of the formal tests in that it showed her pattern of trying to combat the disturbing influence of her strong resentment and anxiety by means of an inhibited and overly compliant way of dealing with materials and situations. At the same time the play interview showed the child's inability to maintain these inhibitory defenses and the way in which the more primitive and direct expression of her state of psychological tension comes to the fore again and again.

Summary and Conclusion

A battery of psychological tests was administered to a 6½-year-old child. The results were described and interpreted, leading to an integrated view of the child's mental functioning and maladjustment status. The manner in which the total picture was pieced together on the basis of information obtained from various tests was demonstrated. In conclusion it is thought that the clinical psychologist can best obtain a comprehensive picture of the psychological functioning of maladjusted children by means of a battery of tests including both intelligence tests and diagnostic personality tests.

Kansas Academy of Science
Annual Report of the Secretary

The minutes of the 76th annual meeting of the Academy held at Topeka, April 15, 1944 were prepared and have been printed in volume 47 (page 283) of the *Transactions*. An account of the meeting was published in *Science* for June 23, 1944, pages 516-517, and in these *Transactions*, volume 47, page 122.

3,000 letterheads and envelopes and 500 dues cards in May, 1944 were ordered from the Kimball Printing Co. at a cost of $40.00. 800 preliminary announcements were printed by the same company in February, 1945 at a cost of $11.75.

The dues cards and announcements were mailed to the membership February 21, 1945.

The status of the membership at the present date (April 14, 1945) is included herewith.

Honorary Members	7
Life Members	65
Annual Members	
Paid for 1944	388
In arrears one year	71
Junior Academy Clubs	8
Junior Academy Clubs in arrears	6
Institutions or Libraries	10
Total	555

During the year, 70 new members have joined the Academy and 18 have been reinstated. The following members resigned during the year: C. O. Barnard, V. E. Bottom, Roberta Enns, Marie Graham, Margaret H. Haggart, Russel M. Jeffords, Donald M. Johnson, Thaine Johnson, Ben Franklin Club, Garden City Schools Service Club, Hazel M. Fletcher, Richard J. W. Koopman, Clyde McCormick, Elizabeth McCracken, W. H. Mikesell, G. Baley Price, Suzanne Reichard, Mayo G. Shultz, Cecil E. Smith, Henry Voth, Hugo Wall, Mary Elvira Weeks, R. Stephen White, and H. D. Young.

Miss Mary Teaford has most capably assisted the Secretary through the year.

DONALD J. AMEEL, *Secretary.*

Minutes and Reports of the 77th Annual Meeting, Manhattan, Kansas, April 14, 1945

The 77th annual meeting of the Kansas Academy of Science was held at Manhattan, Kansas, April 14, 1945. The Executive Council consisting of L. D. Bushnell, J. W. Breukelman, D. J. Ameel, F. W. Albertson, P. S. Riggs, Robert Taft, W. J. Baumgartner, and Miss Edith Beach met at 8:30 a.m., Saturday, April 14, and transacted the following business:

1. It was agreed that, in consideration of the current situation, the 1946 place of meeting be determined later by the executive committee. It was suggested that Emporia be given first choice if conditions permitted.
2. It was agreed that the accumulated interest from the funds of the Academy, other than that from the Reagan fund, be placed in our general fund for the 1945-46 Academy year.
3. It was agreed to present certain amendments of the constitution and by-laws to the membership at the general meetings for approval.

At the general business meeting at 11:00 a.m. on Saturday, April 14, the Academy transacted the following business:

1. Due to insufficient time, the Academy dispensed with the reading of the minutes of the last business meeting held at Topeka, Kansas, Saturday, April 15, 1944.
2. The amendments of the constitution and by-laws were read to the membership.

At the general business meeting at 4:15 p.m. on Saturday, April 14, 1945, the Academy transacted the following business:

By agreement the society considered that the business transacted this hour was on a different day from the 8:30 a.m. council meeting, and the 11:00 a.m. business meeting held this same calendar day, so that business presented at either of those sessions could be voted on by the membership at this session. This procedure was necessitated by the one day meeting.

1. The report of the secretary was presented and accepted.
2. The report of the Academy delegate was presented and accepted.
3. The committee on state aid reported that the Academy has been granted $600 annually by the state for the next two years.
4. Inasmuch as there were no applications for research awards, it was voted to extend the deadline for their receipt until May 14, 1945.

5. The managing editor reported on the second class mailing arrangement for the distribution of the Transactions. He pointed out that though the quarterly publication of the Transactions has increased the cost of their publication, certain of this cost was offset by the reduction in the cost of mailing second class.

6. The report of the necrology committee was presented and accepted.

7. The report of the treasurer was presented and accepted.

8. It was voted to empower the treasurer to cash in sufficient Academy bonds to cover the current deficit.

9. It was voted that the accumulated interest from the funds of the Academy, other than that from the Reagan fund, be placed in our general fund for the 1945-46 Academy year.

10. The report of the auditing committee was presented and accepted.

11. The report of the resolutions committee was read and accepted. The report read as follows:

> In view of the added efforts of the Kansas Academy necessary on account of the demands made upon its individual members and the limitations which circumstances have imposed upon it and which it cheerfully accepts, be it resolved:
>
> 1. That the Academy commend the executive council for making provision for this limited meeting which has proved a stimulation to all present.
>
> 2. That the Academy express its appreciation to Kansas State College at Manhattan for extending its facilities to the Academy for conducting its various sessions and especially to Radio Station KSAC for the broadcast which made it possible for absent members to enjoy a part of the meeting. Also, acknowledgement should be made to the cafeteria for providing an excellent lunch notwithstanding the difficulties arising from the ration problem.
>
> 3. That the Academy extend its thanks to the local committee for the complete and satisfactory arrangements for this meeting. This list should include Dr. Chelikowsky, Dr. Vail, Mr. Bryson, Mr. Parrish and Miss Stebbins.
>
> 4. That we express our gratitude to Dr. Walter F. Loehwing, Botany Department, University of Iowa, for his interesting and instructive public address on "Recent Advances in Plant Science."

5. That the Academy along with the other citizens of our country mourn the pasisng of our chief executive, President Roosevelt, and that it realizes more than ever the need for continuing to an even greater extent the purposes of the war effort and that we give our support to President Truman in carrying on the work of our government.

6. That the Academy approve the work of the editorial board and particularly Dr. Robert Taft, Editor-in-Chief of the Transactions of the Academy of Science for making the Transactions a quarterly publication instead of an annual publication.

12. The committee on Educational Trends and Science Teaching reported very little activity during the year.

13. The membership voted in favor of the amendments to the constitution and by-laws suggested at the morning meeting. (These have been published in the June number of volume 48 of the *Transactions.*)

14. The nominating committee reported as follows: President, Dr. John W. Breukelman; President-elect, Dr. Claude W. Hibbard; Vice-President, Dr. John C. Peterson; Secretary, Dr. Donald J. Ameel; Treasurer, Dr. F. W. Albertson; Executive Council Members, Dr. L. D. Bushnell, Dr. H. H. Lane, Dr. Paul Murphy, and Miss Edith Beach; Associate Editors, Dr. Mary T. Harman (3 years), Dr. A. B. Cardwell (3 years), and Dr. W. H. Schoewe (2 years); Librarian, Dr. M. J. Harbaugh.

15. It was voted that the names of persons now in the armed services be kept on record for the 1945-46 Academy year regardless of the payment of dues.

The Executive Council for 1945-46 convened at 5:00 p.m. with President Breukleman in the chair, at which time the following business was transacted:

1. It was voted to make available an allotment up to $100 for the work of the Junior Academy.

2. The Executive Committee was empowered to allot funds in case other committees became active during the year and should require them.

3. The council approved the suggestion of Dr. Albertson that the money received from bonds maturing in 1945 should be used to meet the current deficit and that the residue should be invested in government bonds.

4. It was agreed to endorse a double-the-membership campaign, the Academy president to write a letter appealing to the membership.

5. It was voted to appoint Miss Beach coordinator of the state Science Clubs of America.

6. It was agreed that no one should be reimbursed for expenses incurred while attending the annual meeting.

—DONALD J. AMEEL, *Secretary.*

Kansas Academy of Science
Report of the Treasurer

April 10, 1944, to April 11, 1945

Receipts

Balance in checking account, April 10, 1944		$ 264.99
Annual dues for membership		461.05
Three life membership fees		56.00
Sale of "Science and the War"		1.00
Sale of Transactions		2.75
Sale of Winter Twigs		21.54
Reprints		143.95
State of Kansas		600.00
Interest on Investments		
Reagan Bond	$ 25.00	
First Federal Savings	2.36	
Greene Co. Bldg. & Loan	9.20	
U. S. Treasury Bonds	32.63	
The Morris Plan	8.04	77.23
		$1,628.51

Disbursements

Awards:		
Dorothea Franzen	$ 55.00	
L. G. Gier—1943	6.38	
L. G. Gier—1944	15.00	$ 76.38
Secretary—stationery, help, express charges, stamps, telephone calls, etc.		242.86
Treasurer—lock box, report		3.90
Editorial Board		
Managing Editor—envelopes, etc.	$ 99.82	
Engraving (No. 1, 2 and 3)	280.57	380.39

Editor		
Printing—September Issue, *Transactions*	$506.00	
Postage	31.70	537.70
Sectional Chairmen		
Zoology Section		1.50
Junior Academy		17.39
Committee on Trends		52.69
		$1,312.81
Return of check		2.00
		$1,314.81
Balance in checking account, April 11, 1945		313.70
		$1,628.51

Supplementary Statement

Accounts Receivable		
Reprints No. 1, 2, and 3 (Vol. 47)	$139.63	
Exchange rights	500.00	
A. A. A. S. award	64.50	
		$ 704.13
Accounts Payable		
Printing *Transactions*, No. 2	$600.20	
Printing *Transactions*, No. 3	563.30	
		$1,163.30

F. W. Albertson, *Treasurer.*

Transactions

Kansas Academy of Science

Volume 48, No. 3 December, 1945

Science—The Endless Frontier*

VANNEVAR BUSH

Director, U. S. Office of Scientific Research and Development

On November 17,1944, President Roosevelt requested recommendations from Dr. Bush on the following points:

(1) What can be done, consistent with military security, and with the prior approval of the military authorities, to make known to the world as soon as possible the contributions which have been made during our war effort to scientific knowledge?

(2) With particular reference to the war of science against disease, what can be done now to organize a program for continuing in the future the work which has been done in medicine and related sciences?

(3) What can the Government do now and in the future to aid research activities by public and private organizations?

(4) Can an effective program be proposed for discovering and developing scientific talent in American youth so that the continuing future of scientific research in this country may be assured on a level comparable to what has been done during the war?

In order to answer these questions, four advisory committees were appointed to gather information and to consider the problems involved. In July, 1945, Dr. Bush, after considering the individual committee reports, prepared his answers to the questions raised by President Roosevelt and submitted his recommendations to President Truman; the resulting document, save for minor editorial changes, is the article presented herewith. The editor believes that it may well become a landmark in American scientific history and as such is worthy of the consideration of all citizens, especially those of the scientific profession.

For further information concerning the author, the advisory committee reports and the present status of legislation based on Dr. Bush's recommendations, see page 265—THE EDITOR.

INTRODUCTION

Scientific Progress Is Essential.—We all know how much the new drug, penicillin, has meant to our grievously wounded men on the grim battlefronts of this war—the countless lives it has saved—

*Reprinted from the report of the same title, *Science—The Endless Frontier*, Washington, 1945, pages 5-34. It will be obvious to the reader that the report was prepared before news of the atomic bomb was released to the public.

the incalculable suffering which its use has prevented. Science and the great practical genius of this nation made this achievement possible.

Some of us know the vital role which radar has played in bringing the United Nations to victory over Nazi Germany and in driving the Japanese steadily back from their island bastions. Again it was painstaking scientific research over many years that made radar possible.

What we often forget are the millions of pay envelopes on a peacetime Saturday night which are filled because new products and new industries have provided jobs for countless Americans. Science made that possible, too.

In 1939 millions of people were employed in industries which did not even exist at the close of the last war—radio, air conditioning, rayon and other synthetic fibers, and plastics are examples of the products of these industries. But these things do not mark the end of progress—they are but the beginning if we make full use of our scientific resources. New manufacturing industries can be started and many older industries greatly strengthened and expanded if we continue to study nature's laws and apply new knowledge to practical purposes.

Great advances in agriculture are also based upon scientific research. Plants which are more resistant to disease and are adapted to short growing seasons, the prevention and cure of livestock diseases, the control of our insect enemies, better fertilizers, and improved agricultural practices, all stem from painstaking scientific research.

Advances in science when put to practical use mean more jobs, higher wages, shorter hours, more abundant crops, more leisure for recreation, for study, for learning how to live without the deadening drudgery which has been the burden of the common man for ages past. Advances in science will also bring higher standards of living, will lead to the prevention or cure of diseases, will promote conservation of our limited national resources, and will assure means of defense against aggression. But to achieve these objectives—to secure a high level of employment, to maintain a position of world leadership—the flow of new scientific knowledge must be both continuous and substantial.

Our population increased from 75 million to 130 million between 1900 and 1940. In some countries comparable increases have been accompanied by famine. In this country the increase has been

accompanied by more abundant food supply, better living, more leisure, longer life, and better health. This is, largely, the product of three factors—the free play of initiative of a vigorous people under democracy, the heritage of great natural wealth, and the advance of science and its application.

Science, by itself, provides no panacea for individual, social, and economic ills. It can be effective in the national welfare only as a member of a team, whether the conditions be peace or war. But without scientific progress no amount of achievement in other directions can insure our health, prosperity, and security as a nation in the modern world.

Science Is a Proper Concern of Government.—It has been basic United States policy that Government should foster the opening of new frontiers. It opened the seas to clipper ships and furnished land for pioneers. Although these frontiers have more or less disappeared, the frontier of science remains. It is in keeping with the American tradition—one which has made the United States great—that new frontiers shall be made accessible for development by all American citizens.

Moreover, since health, well-being, and security are proper concerns of Government, scientific progress is, and must be, of vital interest to Government. Without scientific progress the national health would deteriorate; without scientific progress we could not hope for improvement in our standard of living or for an increased number of jobs for our citizens; and without scientific progress we could not have maintained our liberties against tyranny.

Government Relations to Science—Past and Future.—From early days the Government has taken an active interest in scientific matters. During the nineteenth century the Coast and Geodetic Survey, the Naval Observatory. the Department of Agriculture, and the Geological Survey were established. Through the Land Grant College Acts the Government has supported research in state institutions for more than 80 years on a gradually increasing scale. Since 1900 a large number of scientific agencies have been established within the Federal Government, until in 1939 they numbered more than 40.

Much of the scientific research done by Government agencies is intermediate in character between the two types of work commonly referred to as basic and applied research. Almost all Government scientific work has ultimate practical objectives but, in many fields of broad national concern, it commonly involves long-term investiga-

tion of a fundamental nature. Generally speaking, the scientific agencies of Government are not so concerned with immediate practical objectives as are the laboratories of industry nor, on the other hand, are they as free to explore any natural phenomena without regard to possible economic applications as are the educational and private research institutions. Government scientific agencies have splendid records of achievement, but they are limited in function.

We have no national policy for science. The Government has only begun to utilize science in the nation's welfare. There is no body within the Government charged with formulating or executing a national science policy. There are no standing committees of the Congress devoted to this important subject. Science has been in the wings. It should be brought to the center of the stage—for in it lies much of our hope for the future.

There are areas of science in which the public interest is acute but which are likely to be cultivated inadequately if left without more support than will come from private sources. These areas—such as research on military problems, agriculture, housing, public health, certain medical research, and research involving expensive capital facilities beyond the capacity of private institutions—should be advanced by active Government support. To date, with the exception of the intensive war research conducted by the Office of Scientific Research and Development, such support has been meager and intermittent.

For reasons presented in this report we are entering a period when science needs and deserves increased support from public funds.

Freedom of Inquiry Must Be Preserved.—The publicly and privately supported colleges, universities, and research institutes are the centers of basic research. They are the wellsprings of knowledge and understanding. As long as they are vigorous and healthy and their scientists are free to pursue the truth wherever it may lead, there will be a flow of new scientific knowledge to those who can apply it to practical problems in Government, in industry, or elsewhere.

Many of the lessons learned in the war-time application of science under Government can be profitably applied in peace. The Government is peculiarly fitted to perform certain functions, such as the coordination and support of broad programs on problems of great national importance. But we must proceed with caution in carrying over the methods which work in wartime to the very dif-

ferent conditions of peace. We must remove the rigid controls which we have had to impose, and recover freedom of inquiry and that healthy competitive scientific spirit so necessary for expansion of the frontiers of scientific knowledge.

Scientific progress on a broad front results from the free play of free intellects, working on subjects of their own choice, in the manner dictated by their curiosity for exploration of the unknown. Freedom of inquiry must be preserved under any plan for Government support of science in accordance with the Five Fundamentals listed on page 255.

The study of the momentous questions presented in President Roosevelt's letter has been made by able committees working diligently. This report presents conclusions and recommendations based upon the studies of these committees which appear in full as the appendices. Only in the creation of one over-all mechanism rather than several does this report depart from the specific recommendations of the committees. The members of the committees have reviewed the recommendations in regard to the single mechanism and have found this plan thoroughly acceptable.

THE WAR AGAINST DISEASE

In War.—The death rate for all diseases in the Army, including the overseas forces, has been reduced from 14.1 per thousand in the last war to 0.6 per thousand in this war.

Such ravaging diseases as yellow fever, dysentery, typhus, tetanus, pneumonia, and meningitis have been all but conquered by penicillin and the sulfa drugs, the insecticide DDT, better vaccines, and improved hygienic measures. Malaria has been controlled. There has been dramatic progress in surgery.

The striking advances in medicine during the war have been possible only because we had a large backlog of scientific data accumulated through basic research in many scientific fields in the years before the war.

In Peace.—In the last 40 years life expectancy in the United States has increased from 49 to 65 years largely as a consequence of the reduction in the death rates of infants and children; in the last 20 years the death rate from the diseases of childhood has been reduced 87 percent.

Diabetes has been brought under control by insulin, pernicious anemia by liver extracts; and the once widespread deficiency dis-

eases have been much reduced, even in the lowest income groups, by accessory food factors and improvement of diet. Notable advances have been made in the early diagnosis of cancer, and in the surgical and radiation treatment of the disease.

These results have been achieved through a great amount of basic research in medicine and the preclinical sciences, and by the dissemination of this new scientific knowledge through the physicians and medical services and public health agencies of the country. In this cooperative endeavour the pharmaceutical industry has played an important role, especially during the war. All of the medical and public health groups share credit for these achievements; they form interdependent members of a team.

Progress in combating disease depends upon an expanding body of new scientific knowledge.

Unsolved Problems.—As President Roosevelt observed, the annual deaths from one or two diseases are far in excess of the total number of American lives lost in battle during this war. A large fraction of these deaths in our civilian population cut short the useful lives of our citizens. This is our present position despite the fact that in the last three decades notable progress has been made in civilian medicine. The reduction in death rate from diseases of childhood has shifted the emphasis to the middle and old age groups, particularly to the malignant diseases and the degenerative processes prominent in later life. Cardiovascular disease, including chronic disease of the kidneys, arteriosclerosis, and cerebral hemorrhage, now account for 45 percent of the deaths in the United States. Second are the infectious diseases, and third is cancer. Added to these are many maladies (for example, the common cold, arthritis, asthma and hay fever, peptic ulcer) which, though infrequently fatal, cause incalculable disability.

Another aspect of the changing emphasis is the increase of mental diseases. Approximately 7 million persons in the United States are mentally ill; more than one-third of the hospital beds are occupied by such persons, at a cost of $175 million a year. Each year 125,000 new mental cases are hospitalized.

Notwithstanding great progress in prolonging the span of life and in relief of suffering, much illness remains for which adequate means of prevention and cure are not yet known. While additional physicians, hospitals, and health programs are needed, their full usefulness cannot be attained unless we enlarge our knowledge of the human organism and the nature of disease. Any extension of

medical facilities must be accompanied by an expanded program of medical training and research.

Broad and Basic Studies Needed.—Discoveries pertinent to medical progress have often come from remote and unexpected sources, and it is certain that this will be true in the future. It is wholly probably that progress in the treatment of cardiovascular disease, renal disease, cancer, and similar refractory diseases will be made as the result of fundamental discoveries in subjects unrelated to those diseases, and perhaps entirely unexpected by the investigator. Further progress requires that the entire front of medicine and the underlying sciences of chemistry, physics, anatomy, biochemistry, physiology, pharmacology, bacteriology, pathology, parasitology, etc., be broadly developed.

Progress in the war against disease results from discoveries in remote and unexpected fields of medicine and the underlying sciences.

Coordinated Attack on Special Problems.—Penicillin reached our troops in time to save countless lives because the Government coordinated and supported the program of research and development on the drug. The development moved from the early laboratory stage to large scale production and use in a fraction of the time it would have taken without such leadership. The search for better anti-malarials, which proceeded at a moderate tempo for many years, has been accelerated enormously by Government support during the war. Other examples can be cited in which medical progress has been similarly advanced. In achieving these results, the Government has provided over-all coordination and support; it has not dictated how the work should be done within any cooperating institution.

Discovery of new therapeutic agents and methods usually results from basic studies in medicine and the underlying sciences. The development of such materials and methods to the point at which they become available to medical practitioners requires teamwork involving the medical schools, the science departments of universities, Government and the pharmaceutical industry. Government initiative, support, and coordination can be very effective in this development phase.

Government initiative and support for the development of newly discovered therapeutic materials and methods can reduce the time required to bring the benefits to the public.

Action is Necessary.—The primary place for medical research is in the medical schools and universities. In some cases coordinated direct attack on special problems may be made by teams of investigators, supplementing similar attacks carried on by the Army, Navy, Public Health Service, and other organizations. Apart from teaching, however, the primary obligation of the medical schools and universities is to continue the traditional function of such institutions, namely, to provide the individual worker with an opportunity for free, untrammeled study of nature, in the directions and by the methods suggested by his interests, curiosity, and imagination. The history of medical science teaches clearly the supreme importance of affording the prepared mind complete freedom for the exercise of initiative. It is the special province of the medical schools and universities to foster medical research in this way—a duty which cannot be shifted to government agencies, industrial organizations, or to any other institutions.

Where clinical investigations of the human body are required, the medical schools are in a unique position, because of their close relationship to teaching hospitals, to integrate such investigations with the work of the departments of preclinical science, and to impart new knowledge to physicians in training. At the same time, the teaching hospitals are especially well qualified to carry on medical research because of their close connection with the medical schools, on which they depend for staff and supervision.

Between World War I and World War II the United States overtook all other nations in medical research and assumed a position of world leadership. To a considerable extent this progress reflected the liberal financial support from university endowment income, gifts from individuals, and foundation grants in the 20's. The growth of research departments in medical schools has been very uneven, however, and in consequence most of the important work has been done in a few large schools. This should be corrected by building up the weaker institutions, especially in regions which now have no strong medical research activities.

The traditional sources of support for medical research, largely endowment income, foundation grants, and private donations, are diminishing, and there is no immediate prospect of a change in this trend. Meanwhile, research costs have steadily risen. More elaborate and expensive equipment is required, supplies are more costly, and the wages of assistants are higher. Industry is only to a limited extent a source of funds for basic medical research.

It is clear that if we are to maintain the progress in medicine which has marked the last 25 years, the Government should extend financial support to basic medical research in the medical schools and in the universities, through grants both for research and for fellowships. The amount which can be effectively spent in the first year should not exceed 5 million dollars. After a program is under way perhaps 20 million dollars a year can be spent effectively.

SCIENCE AND THE PUBLIC WELFARE

Relation to National Security.—In this war it has become clear beyond all doubt that scientific research is absolutely essential to national security. The bitter and dangerous battle against the U-boat was a battle of scientific techniques—and our margin of success was dangerously small. The new eyes which radar supplied to our fighting forces quickly evoked the development of scientific countermeasures which could often blind them. This again represents the ever continuing battle of techniques. The V-1 attack on London was finally defeated by three devices developed during this war and used superbly in the field. V-2 was countered only by capture of the launching sites.

The Secretaries of War and Navy recently stated in a joint letter to the National Academy of Sciences:

> This war emphasizes three facts of supreme importance to national security: (1) Powerful new tactics of defense and offense are developed around new weapons created by scientific and engineering research; (2) the competitive time element in developing those weapons and tactics may be decisive; (3) war is increasingly total war, in which the armed services must be supplemented by active participation of every element of civilian population.
>
> To insure continued preparedness along farsighted technical lines, the research scientists of the country must be called upon to continue in peacetime some substantial portion of those types of contribution to national security which they have made so effectively during the stress of the present war * * *.

There must be more—and more adequate—military research during peacetime. We cannot again rely on our allies to hold off the enemy while we struggle to catch up. Further, it is clear that only the Government can undertake military research; for it must be carried on in secret, much of it has no commercial value, and it is expensive. The obligation of Government to support research on military problems is inescapable.

Modern war requires the use of the most advanced scientific techniques. Many of the leaders in the development of radar are scientists who before the war had been exploring the nucleus of the atom. While there must be increased emphasis on science in the

future training of officers for both the Army and Navy, such men cannot be expected to be specialists in scientific research. Therefore a professional partnership between the officers in the Services and civilian scientists is needed.

The Army and Navy should continue to carry on research and development on the improvement of current weapons. For many years the National Advisory Committee for Aeronautics has supplemented the work of the Army and Navy by conducting basic research on the problems of flight. There should now be permanent civilian activity to supplement the research work of the Services in other scientific fields so as to carry on in time of peace some part of the activities of the emergency war-time Office of Scientific Research and Development.

Military preparedness requires a permanent independent, civilian-controlled organization, having close liaison with the Army and Navy, but with funds directly from Congress and with the clear power to initiate military research which will supplement and strengthen that carried on directly under the control of the Army and Navy.

Science and Jobs—One of our hopes is that after the war there will be full employment, and that the production of goods and services will serve to raise our standard of living. We do not know yet how we shall reach that goal, but it is certain that it can be achieved only by releasing the full creative and productive energies of the American people.

Surely we will not get there by standing still, merely by making the same things we made before and selling them at the same or higher prices. We will not get ahead in international trade unless we offer new and more attractive and cheaper products.

Where will these new products come from? How will we find ways to make better products at lower cost? The answer is clear. There must be a stream of new scientific knowledge to turn the wheels of private and public enterprise. There must be plenty of men and women trained in science and technology for upon them depend both the creation of new knowledge and its application to practical purposes.

More and better scientific research is essential to the achievement of our goal of full employment.

The Importance of Basic Research.—Basic research is performed without thought of practical ends. It results in general knowledge and an understanding of nature and its laws. This general knowledge

provides the means of answering a large number of important practical problems, though it may not give a complete specific answer to any one of them. The function of applied research is to provide such complete answers. The scientist doing basic research may not be at all interested in the practical applications of his work, yet the further progress of industrial development would eventually stagnate if basic scientific research were long neglected.

One of the peculiarities of basic science is the variety of paths which lead to productive advance. Many of the most important discoveries have come as a result of experiments undertaken with very different purposes in mind. Statistically it is certain that important and highly useful discoveries will result from some fraction of the undertakings in basic science; but the results of any one particular investigation cannot be predicted with accuracy.

Basic research leads to new knowledge. It provides scientific capital. It creates the fund from which the practical applications of knowledge must be drawn. New products and new processes do not appear full-grown. They are founded on new principles and new conceptions, which in turn are painstakingly developed by research in the purest realms of science.

Today, it is truer than ever that basic research is the pacemaker of technological progress. In the nineteenth century, Yankee mechanical ingenuity, building largely upon the basic discoveries of European scientists, could greatly advance the technical arts. Now the situation is different.

A nation which depends upon others for its new basic scientific knowledge will be slow in its industrial progress and weak in its competitive position in world trade, regardless of its mechanical skill.

Centers of Basic Research.—Publicly and privately supported colleges and universities and the endowed research institutes must furnish both the new scientific knowledge and the trained research workers. These institutions are uniquely qualified by tradition and by their special characteristics to carry on basic research. They are charged with the responsibility of conserving the knowledge accumulated by the past, imparting that knowledge to students, and contributing new knowledge of all kinds. It is chiefly in these institutions that scientists may work in an atmosphere which is relatively free from the adverse pressure of convention, prejudice, or commercial necessity. At their best they provide the scientific worker with a strong sense of solidarity and security, as well as a substan-

tial degree of personal intellectual freedom. All of these factors are of great importance in the development of new knowledge, since much of new knowledge is certain to arouse opposition because of its tendency to challenge current beliefs or practice.

Industry is generally inhibited by preconceived goals, by its own clearly defined standards, and by the constant pressure of commercial necessity. Satisfactory progress in basic science seldom occurs under conditions prevailing in the normal industrial laboratory. There are some notable exceptions, it is true, but even in such cases it is rarely possible to match the universities in respect to the freedom which is so important to scientific discovery.

To serve effectively as the centers of basic research these institutions must be strong and healthy. They must attract our best scientists as teachers and investigators. They must offer research opportunities and sufficient compensation to enable them to compete with industry and government for the cream of scientific talent.

During the past 25 years there has been a great increase in industrial research involving the application of scientific knowledge to a multitude of practical purposes—thus providing new products, new industries, new investment opportunities, and millions of jobs. During the same period research within Government—again largely applied research—has also been greatly expanded. In the decade from 1930 to 1940 expenditures for industrial research increased from $116,000,000 to $240,000,000 and those for scientific research in Government rose from $24,000,000 to $69,000,000. During the same period expenditures for scientific research in the colleges and universities increased from $20,000,000 to $31,000,000, while those in the endowed research institutes declined from $5,200,000 to $4,500,000. These are the best estimates available. The figures have been taken from a variety of sources and arbitrary definitions have necessarily been applied, but it is believed that they may be accepted as indicating the following trends:

(a) Expenditures for scientific research by industry and Government—almost entirely applied research—have more than doubled between 1930 and 1940. Whereas in 1930 they were six times as large as the research expenditures of the colleges, universities, and research institutes, by 1940 they were nearly ten times as large.

(b) While expenditures for scientific research in the colleges and universities increased by one-half during this period, those for the endowed research institutes have slowly declined.

If the colleges, universities, and research institutes are to meet the rapidly increasing demands of industry and Government for new scientific knowledge, their basic research should be strengthened by use of public funds.

Research Within the Government.—Although there are some notable exceptions, most research conducted within governmental laboratories is of an applied nature. This has always been true and is likely to remain so. Hence Government, like industry, is dependent upon the colleges, universities, and research institutes to expand the basic scientific frontiers and to furnish trained scientific investigators.

Research within the Government represents an important part of our total research activity and needs to be strengthened and expanded after the war. Such expansion should be directed to fields of inquiry and service which are of public importance and are not adequately carried on by private organizations.

The most important single factor in scientific and technical work is the quality of personnel employed. The procedures currently followed within the Government for recruiting, classifying and compensating such personnel place the Government under a severe handicap in competing with industry and the universities for first-class scientific talent. Steps should be taken to reduce that handicap.

In the Government the arrangement whereby the numerous scientific agencies form parts of larger departments has both advantages and disadvantages. But the present pattern is firmly established and there is much to be said for it. There is, however, a very real need for some measure of coordination of the common scientific activities of these agencies, both as to policies and budgets, and at present no such means exist.

A permanent Science Advisory Board should be created to consult with these scientific bureaus and to advise the executive and legislative branches of Government as to the policies and budgets of Government agencies engaged in scientific research.

This board should be composed of disinterested scientists who have no connection with the affairs of any Government agency.

Industrial Research.—The simplest and most effective way in which the Government can strengthen industrial research is to support basic research and to develop scientific talent.

The benefits of basic research do not reach all industries equally or at the same speed. Some small enterprises never receive any of the benefits. It has been suggested that the benefits might be better

utilized if "research clinics" for such enterprises were to be established. Businessmen would thus be able to make more use of research than they now do. This proposal is certainly worthy of further study.

One of the most important factors affecting the amount of industrial research is the income-tax law. Government action in respect to this subject will affect the rate of technical progress in industry. Uncertainties as to the attitude of the Bureau of Internal Revenue regarding the deduction of research and development expenses are a deterrent to research expenditure. These uncertainties arise from lack of clarity of the tax law as to the proper treatment of such costs.

The Internal Revenue Code should be amended to remove present uncertainties in regard to the deductibility of research and development expenditures as current charges against net income.

Research is also affected by the patent laws. They stimulate new invention and they make it possible for new industries to be built around new devices or new processes. These industries generate new jobs and new products, all of which contribute to the welfare and the strength of the country.

Yet, uncertainties in the operation of the patent laws have impaired the ability of small industries to translate new ideas into processes and products of value to the nation. These uncertainties are, in part, attributable to the difficulties and expense incident to the operation of the patent system as it presently exists. These uncertainties are also attributable to the existence of certain abuses, which have appeared in the use of patents. The abuses should be corrected. They have led to extravagantly critical attacks which tend to discredit a basically sound system.

It is important that the patent system continue to serve the country in the manner intended by the Constitution, for it has been a vital element in the industrial vigor which has distinguished this nation.

The National Patent Planning Commission has reported on this subject. In addition, a detailed study, with recommendations concerning the extent to which modifications should be made in our patent laws is currently being made under the leadership of the Secretary of Commerce. It is recommended, therefore, that specific action with regard to the patent laws be withheld pending the submission of the report devoted exclusively to that subject.

International Exchange of Scientific Information.—International exchange of scientific information is of growing importance. Increasing specialization of science will make it more important than ever that scientists in this country keep continually abreast of developments abroad. In addition a flow of scientific information constitutes one facet of general international accord which should be cultivated.

The Government can accomplish significant results in several ways: by aiding in the arrangement of international science congresses, in the official accrediting of American scientists to such gatherings, in the official reception of foreign scientists of standing in this country, in making possible a rapid flow of technical information, including translation service, and possibly in the provision of international fellowships. Private foundations and other groups partially fulfill some of these functions at present, but their scope is incomplete and inadequate.

The Government should take an active role in promoting the international flow of scientific information.

The Special Need for Federal Support.—We can no longer count on ravaged Europe as a source of fundamental knowledge. In the past we have devoted much of our best efforts to the application of such knowledge which has been discovered abroad. In the future we must pay increased attention to discovering this knowledge for ourselves particularly since the scientific applications of the future will be more than ever dependent upon such basic knowledge.

New impetus must be given to research in our country. Such new impetus can come promptly only from the Government. Expenditures for research in the colleges, universities, and research institutes will otherwise not be able to meet the additional demands of increased public need for research.

Further, we cannot expect industry adequately to fill the gap. Industry will fully rise to the challenge of applying new knowledge to new products. The commercial incentive can be relied upon for that. But basic research is essentially noncommercial in nature. It will not receive the attention it requires if left to industry.

For many years the Government has wisely supported research in the agricultural colleges and the benefits have been great. The time has come when such support should be extended to other fields.

In providing Government support, however, we must endeavor to preserve as far as possible the private support of research both in industry and in the colleges, universities, and research institutes.

These private sources should continue to carry their share of the financial burden.

The Cost of a Program.—It is estimated that an adequate program for Federal support of basic research in the colleges, universities, and research institutes and for financing important applied research in the public interest, will cost about 10 million dollars at the outset and may rise to about 50 million dollars annually when fully underway at the end of perhaps 5 years.

RENEWAL OF OUR SCIENTIFIC TALENT

Nature of the Problem.—The responsibility for the creation of new scientific knowledge rests on that small body of men and women who understand the fundamental laws of nature and are skilled in the techniques of scientific research. While there will always be the rare individual who will rise to the top without benefit of formal education and training, he is the exception and even he might make a more notable contribution if he had the benefit of the best education we have to offer. I cannot improve on President Conant's statement that:

"* * * in every section of the entire area where the word science may properly be applied, the limiting factor is a human one. We shall have rapid or slow advance in this direction or in that depending on the number of really first-class men who are engaged in the work in question. * * * So in the last analysis, the future of science in this country will be determined by our basic educational policy."

A Note of Warning.—It would be folly to set up a program under which research in the natural sciences and medicine was expanded at the cost of the social sciences, humanities, and other studies so essential to national well-being. This point has been well stated by the Moe Committee* as follows:

"As citizens, as good citizens, we therefore think that we must have in mind while examining the question before us—the discovery and development of scientific talent—the needs of the whole national welfare. We could not suggest to you a program which would syphon into science and technology a disproportionately large share of the nation's highest abilities, without doing harm to the nation, nor, indeed, without crippling science. * * * Science cannot live by and unto itself alone."

* * * * * * *

"The uses to which high ability in youth can be put are various and, to a large extent, are determined by social pressures and rewards. When aided by selective devices for picking out scientifically talented youth, it is clear that large sums of money for scholarships and fellowships and monetary and other rewards in disproportionate amounts might draw into science too large a percentage of the nation's high ability, with a result highly detrimental to the nation and to science. Plans for the discovery and development of scientific talent must be related to the other needs of society for high ability * * * There is never enough ability at high levels to satisfy all the needs of the

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*One of the four advisory committees.

nation; we would not seek to draw into science any more of it than science's proportionate share."

The Wartime Deficit.—Among the young men and women qualified to take up scientific work, since 1940 there have been few students over 18, except some in medicine and engineering in Army and Navy programs and a few 4-F's, who have followed an integrated scientific course of studies. Neither our allies nor, so far as we know, our enemies have done anything so radical as thus to suspend almost completely their educational activities in scientific pursuits during the war period.

Two great principles have guided us in this country as we have turned our full efforts to war. First, the sound democratic principle that there should be no favored classes or special privilege in a time of peril, that all should be ready to sacrifice equally; second, the tenet that every man should serve in the capacity in which his talents and experience can best be applied for the prosecution of the war effort. In general we have held these principles well in balance.

In my opinion, however, we have drawn too heavily for nonscientific purposes upon the great natural resource which resides in our trained young scientists and engineers. For the general good of the country too many such men have gone into uniform, and their talents have not always been fully utilized. With the exception of those men engaged in war research, all physically fit students at graduate level have been taken into the armed forces. Those ready for college training in the sciences have not been permitted to enter upon that training.

There is thus an accumulating deficit of trained research personnel which will continue for many years. The deficit of science and technology students who, but for the war, would have received bachelor's degrees is about 150,000. The deficit of those holding advanced degrees—that is, young scholars trained to the point where they are capable of carrying on original work—has been estimated as amounting to about 17,000 by 1955 in chemistry, engineering, geology, mathematics, physics, psychology, and the biological sciences.

With mounting demands for scientists both for teaching and for research, we will enter the post-war period with a serious deficit in our trained scientific personnel.

Improve the Quality.—Confronted with these deficits, we are compelled to look to the use of our basic human resources and formulate a program which will assure their conservation and effective

development. The committee advising me on scientific personnel has stated the following principle which should guide our planning:

"If we were all-knowing and all-wise we might, but we think probably not, write you a plan whereby there might be selected for training, which they otherwise would not get, those who, 20 years hence, would be scientific leaders, and we might not bother about any lesser manifestations of scientific ability. But in the present state of knowledge a plan cannot be made which will select, and assist, only those young men and women who will give the top future leadership to science. To get top leadership there must be a relatively large base of high ability selected for development and then successive skimmings of the cream of ability at successive times and at higher levels. No one can select from the bottom those who will be the leaders at the top because unmeasured and unknown factors enter into scientific, or any, leadership. There are brains and character, strength and health, happiness and spiritual vitality, interest and motivation, and no one knows what else, that must needs enter into this supra-mathematical calculus.

"We think we probably would not, even if we were all-wise and all-knowing, write you a plan whereby you would be assured of scientific leadership at one stroke. We think as we think because we are not interested in setting up an elect. We think it much the best plan, in this constitutional Republic, that opportunity be held out to all kinds and conditions of men whereby they can better themselves. This is the American way; this is the way the United States has become what it is. We think it very important that circumstances be such that there be no ceilings, other than ability itself, to intellectual ambition. We think it very important that every boy and girl shall know that, if he shows that he has what it takes, the sky is the limit. Even if it be shown subsequently that he has not what it takes to go to the top, he will go further than he would otherwise go if there had been a ceiling beyond which he always knew he could not aspire.

"By proceeding from point to point and taking stock on the way, by giving further opportunity to those who show themselves worthy of further opportunity, by giving the most opportunity to those who show themselves continually developing—this is the way we propose. This is the American way: a man works for what he gets."

Remove the Barriers.—Higher education in this country is largely for those who have the means. If those who have the means coincided entirely with those persons who have the talent we should not be squandering a part of our higher education on those undeserving of it, nor neglecting great talent among those who fail to attend college for economic reasons. There are talented individuals in every segment of the population, but with few exceptions those without the means of buying higher education go without it. Here is a tremendous waste of the greatest resource of a nation—the intelligence of its citizens.

If ability, and not the circumstance of family fortune, is made to determine who shall receive higher education in science, then we shall be assured of constantly improving quality at every level of scientific activity.

The Generation in Uniform Must Not Be Lost.—We have a serious deficit in scientific personnel partly because the men who would have studied science in the colleges and universities have been

serving in the Armed Forces. Many had begun their studies before they went to war. Others with capacity for scientific education went to war after finishing high school. The most immediate prospect of making up some of the deficit in scientific personnel is by salvaging scientific talent from the generation in uniform. For even if we should start now to train the current crop of high school graduates, it would be 1951 before they would complete graduate studies and be prepared for effective scientific research. This fact underlines the necessity of salvaging potential scientists in uniform.

The Armed Services should comb their records for men who, prior to or during the war, have given evidence of talent for science, and make prompt arrangements, consistent with current discharge plans, for ordering those who remain in uniform as soon as militarily possible to duty at institutions here and overseas where they can continue their scientific education. Moreover, they should see that those who study overseas have the benefit of the latest scientific developments.

A Program.—The country may be proud of the fact that 95 percent of boys and girls of fifth grade age are enrolled in school, but the drop in enrollment after the fifth grade is less satisfying. For every 1,000 students in the fifth grade, 600 are lost to education before the end of high school, and all but 72 have ceased formal education before completion of college. While we are concerned primarily with methods of selecting and educating high school graduates at the college and higher levels, we cannot be complacent about the loss of potential talent which is inherent in the present situation.

Students drop out of school, college, and graduate school, or do not get that far, for a variety of reasons: they cannot afford to go on; schools and colleges providing courses equal to their capacity are not available locally; business and industry recruit many of the most promising before they have finished the training of which they are capable. These reasons apply with particular force to science: the road is long and expensive; it extends at least 6 years beyond high school; the percentage of science students who can obtain first-rate training in institutions near home is small.

Improvement in the teaching of science is imperative; for students of latent scientific ability are particularly vulnerable to high school teaching which fails to awaken interest or to provide adequate instruction. To enlarge the group of specially qualified men and women it is necessary to increase the number who go to college. This involves improved high school instruction, provision for help-

ing individual talented students to finish high school (primarily the responsibility of the local communities), and opportunities for more capable, promising high school students to go to college. Anything short of this means serious waste of higher education and neglect of human resources.

To encourage and enable a larger number of young men and women of ability to take up science as a career, and in order gradually to reduce the deficit of trained scientific personnel, it is recommended that provision be made for a reasonable number of (a) undergraduate scholarships and graduate fellowships and (b) fellowships for advanced training and fundamental research. The details should be worked out with reference to the interests of the several States and of the universities and colleges; and care should be taken not to impair the freedom of the institutions and individuals concerned.

The program proposed by the Moe Committee would provide 24,000 undergraduate scholarships and 900 graduate fellowships and would cost about $30,000,000 annually when in full operation. Each year under this program 6,000 undergraduate scholarships would be made available to high school graduates, and 300 graduate fellowships would be offered to college graduates. Approximately the scale of allowances provided for under the educational program for returning veterans has been used in estimating the cost of this program.

The plan is, further, that all those who receive such scholarships or fellowships in science should be enrolled in a National Science Reserve and be liable to call into the service of the Government, in connection with scientific or technical work in time of war or other national emergency declared by Congress or proclaimed by the President. Thus, in addition to the general benefits to the nation by reason of the addition to its trained ranks of such a corps of scientific workers, there would be a definite benefit to the nation in having these scientific workers on call in national emergencies. The Government would be well advised to invest the money involved in this plan even if the benefits to the nation were thought of solely—which they are not—in terms of national preparedness.

A PROBLEM OF SCIENTIFIC RECONVERSION

Effects of Mobilization of Science for War.—We have been living on our fat. For more than 5 years many of our scientists have been fighting the war in the laboratories. in the factories and shops,

and at the front. We have been directing the energies of our scientists to the development of weapons and materials and methods, on a large number of relatively narrow projects initiated and controlled by the Office of Scientific Research and Development and other Government agencies. Like troops, the scientists have been mobilized, and thrown into action to serve their country in time of emergency. But they have been diverted to a greater extend than is generally appreciated from the search for answers to the fundamental problems—from the search on which human welfare and progress depends. This is not a complaint—it is a fact. The mobilization of science behind the lines is aiding the fighting men at the front to win the war and to shorten it; and it has resulted incidentally in the accumulation of a vast amount of experience and knowledge of the application of science to particular problems, much of which can be put to use when the war is over. Fortunately, this country had the scientists—and the time—to make this contribution and thus to advance the date of victory.

Security Restrictions Should Be Lifted Promptly.—Much of the information and experience acquired during the war is confined to the agencies that gathered it. Except to the extent that military security dictates otherwise, such knowledge should be spread upon the record for the benefit of the general public.

Thanks to the wise provision of the Secretary of War and the Secretary of the Navy, most of the results of war-time medical research have been published. Several hundred articles have appeared in the professional journals; many are in process of publication. The material still subject to security classification should be released as soon as possible.

It is my view that most of the remainder of the classified scientific material should be released as soon as there is ground for belief that the enemy will not be able to turn it against us in this war. Most of the information needed by industry and in education can be released without disclosing its embodiments in actual military material and devices. Basically there is no reason to believe that scientists of other countries will not in time rediscover everything we now know which is held in secrecy. A broad dissemination of scientific information upon which further advances can readily be made furnishes a sounder foundation for our national security than a policy of restriction which would impede our own progress although imposed in the hope that possible enemies would not catch up with us.

During the war it has been necessary for selected groups of scientists to work on specialized problems, with relatively little information as to what other groups were doing and had done. Working against time, the Office of Scientific Research and Development has been obliged to enforce this practice during the war, although it was realized by all concerned that it was an emergency measure which prevented the continuous cross-fertilization so essential to fruitful scientific effort.

Our ability to overcome possible future enemies depends upon scientific advances which will proceed more rapidly with diffusion of knowledge than under a policy of continued restriction of knowledge now in our possession.

Need for Coordination.—In planning the release of scientific data and experience collected in connection with the war, we must not overlook the fact that research has gone forward under many auspices—the Army, the Navy, the Office of Scientific Research and Development, the National Advisory Committee for Aeronautics, other departments and agencies of the Government, educational institutions, and many industrial organizations. There have been numerous cases of independent discovery of the same truth in different places. To permit the release of information by one agency and to continue to restrict it elsewhere would be unfair in its effect and would tend to impair the morale and efficiency of scientists who have submerged individual interests in the controls and restrictions of war.

A part of the information now classified which should be released is possessed jointly by our allies and ourselves. Plans for release of such information should be coordinated with our allies to minimize danger of international friction which would result from sporadic uncontrolled release.

A Board to Control Release.—The agency responsible for recommending the release of information from military classification should be an Army, Navy, civilian body, well grounded in science and technology. It should be competent to advise the Secretary of War and the Secretary of the Navy. It should, moreover, have sufficient recognition to secure prompt and practical decisions.

To satisfy these considerations I recommend the establishment of a Board, made up equally of scientists and military men, whose function would be to pass upon the declassification and to control the release for publication of scientific information which is now classified.

Publication Should Be Encouraged.—The release of information from security regulations is but one phase of the problem. The other is to provide for preparation of the material and its publication in a form and at a price which will facilitate dissemination and use. In the case of the Office of Scientific Research and Development, arrangements have been made for the preparation of manuscripts, while the staffs under our control are still assembled and in possession of the records, as soon as the pressure for production of results for this war has begun to relax.

We should get this scientific material to scientists everywhere with great promptness, and at as low a price as is consistent with suitable format. We should also get it to the men studying overseas so that they will know what has happened in their absence.

It is recommended that measures which will encourage and facilitate the preparation and publication of reports be adopted forthwith by all agencies, governmental and private, possessing scientific information released from security control.

THE MEANS TO THE END

New Responsibilities for Government.—One lesson is clear from the reports of the several advisory committees. The Federal Government should accept new responsibilities for promoting the creation of new scientific knowledge and the development of scientific talent in our youth.

The extent and nature of these new responsibilities are set forth in detail in the reports of the committees whose recommendations in this regard are fully endorsed.

In discharging these responsibilities Federal funds should be made available. We have given much thought to the question of how plans for the use of Federal funds may be arranged so that such funds will not drive out of the picture funds from local governments, foundations, and private donors. We believe that our proposals will minimize that effect, but we do not think that it can be completely avoided. We submit, however, that the nation's need for more and better scientific research is such that the risk must be accepted.

It is also clear that the effective discharge of these responsibilities will require the full attention of some over-all agency devoted to that purpose. There should be a focal point within the Government for a concerted program of assisting scientific research conducted outside of Government. Such an agency should furnish the funds needed to support basic research in the colleges and universities,

should coordinate where possible research programs on matters of utmost importance to the national welfare, should formulate a national policy for the Government toward science, should sponsor the interchange of scientific information among scientists and laboratories both in this country and abroad, and should ensure that the incentives to research in industry and the universities are maintained. All of the committees advising on these matters agree on the necessity for such an agency.

The Mechanism.—There are within Government departments many groups whose interests are primarily those of scientific research. Notable examples are found within the Departments of Agriculture, Commerce, Interior, and the Federal Security Agency. These groups are concerned with science as collateral and peripheral to the major problems of those Departments. These groups should remain where they are, and continue to perform their present functions, including the support of agricultural research by grants to the Land Grant Colleges and Experiment Stations, since their largest contribution lies in applying fundamental knowledge to the special problems of the Departments within which they are established.

By the same token these groups cannot be made the repository of the new and large responsibilities in science which belong to the Government and which the Government should accept. The recommendations in this report which relate to research within the Government, to the release of scientific information, to clarification of the tax laws, and to the recovery and development of our scientific talent now in uniform can be implemented by action within the existing structure of the Government. But nowhere in the Governmental structure receiving its funds from Congress is there an agency adapted to supplementing the support of basic research in the universities, both in medicine and the natural sciences; adapted to supporting research on new weapons for both Services; or adapted to administering a program of science scholarships and fellowships.

A new agency should be established, therefore, by the Congress for the purpose. Such an agency, moreover, should be an independent agency devoted to the support of scientific research and advanced scientific education alone. Industry learned many years ago that basic research cannot often be fruitfully conducted as an adjunct to or a subdivision of an operating agency or department. Operating agencies have immediate operating goals and are under constant pressure to produce in a tangible way, for that is the test of their value. None of these conditions is favorable to basic re-

search. Research is the exploration of the unknown and is necessarily speculative. It is inhibited by conventional approaches, traditions, and standards. It cannot be satisfactorily conducted in an atmosphere where it is gauged and tested by operating or production standards. Basic scientific research should not, therefore, be placed under an operating agency whose paramount concern is anything other than research. Research will always suffer when put in competition with operations. The decision that there should be a new and independent agency was reached by each of the committees advising in these matters.

I am convinced that these new functions should be centered in one agency. Science is fundamentally a unitary thing. The number of independent agencies should be kept to a minimum. Much medical progress, for example, will come from fundamental advances in chemistry. Separation of the sciences in tight compartments, as would occur if more than one agency were involved, would retard and not advance scientific knowledge as a whole.

Five Fundamentals.—There are certain basic principles which must underlie the program of Government support for scientific research and education if such support is to be effective and if it is to avoid impairing the very things we seek to foster. These principles are as follows:

(1) Whatever the extent of support may be, there must be stability of funds over a period of years so that long-range programs may be undertaken.

(2) The agency to administer such funds should be composed of citizens selected only on the basis of their interest in and capacity to promote the work of the agency. They should be persons of broad interest in and understanding of the peculiarities of scientific research and education.

(3) The agency should promote research through contracts or grants to organizations outside the Federal Government. It should not operate any laboratories of its own.

(4) Support of basic research in the public and private colleges, universities, and research institutes must leave the internal control of policy, personnel, and the method and scope of the research to the institutions themselves. This is of the utmost importance.

(5) While assuring complete independence and freedom for the nature, scope, and methodology of research carried on in the institutions receiving public funds, and while retaining discretion in

the allocation of funds among such institutions, the Foundation proposed herein must be responsible to the President and the Congress. Only through such responsibility can we maintain the proper relationship between science and other aspects of a democratic system. The usual controls of audits, reports, budgeting, and the like, should, of course, apply to the administrative and fiscal operations of the Foundation, subject, however, to such adjustments in procedure as are necessary to meet the special requirements of research.

Basic research is a long-term process—it ceases to be basic if immediate results are expected on short-term support. Methods should therefore be found which will permit the agency to make commitments of funds from current appropriations for programs of five years duration or longer. Continuity and stability of the program and its support may be expected *(a)* from the growing realization by the Congress of the benefits to the public from scientific research, and *(b)* from the conviction which will grow among those who conduct research under the auspices of the agency that good quality work will be followed by continuing support.

Military Research.—As stated earlier in this report, military preparedness requires a permanent, independent, civilian-controlled organization, having close liaison with the Army and Navy, but with funds direct from Congress and the clear power to initiate military research which will supplement and strengthen that carried on directly under the control of the Army and Navy. As a temporary measure the National Academy of Sciences has established the Research Board for National Security at the request of the Secretary of War and the Secretary of the Navy. This is highly desirable in order that there may be no interruption in the relations between scientists and military men after the emergency wartime Office of Scientific Research and Development goes out of existence. The Congress is now considering legislation to provide funds for this Board by direct appropriation.

I believe that, as a permanent measure, it would be appropriate to add to the agency needed to perform the other functions recommended in this report the responsibilities for civilian-initiated and civilian-controlled military research. The function of such a civilian group would be primarily to conduct long-range scientific research on military problems—leaving to the Services research on the improvement of existing weapons.

Some research on military problems should be conducted, in time of peace as well as in war, by civilians independently of the

military establishment. It is the primary responsibility of the Army and Navy to train the men, make available the weapons, and employ the strategy that will bring victory in combat. The Armed Services cannot be expected to be experts in all of the complicated fields which make it possible for a great nation to fight successfully in total war. There are certain kinds of research—such as research on the improvement of existing weapons—which can best be done within the military establishment. However, the job of long-range research involving application of the newest scientific discoveries to military needs should be the responsibility of those civilian scientists in the universities and in industry who are best trained to discharge it thoroughly and successfully. It is essential that both kinds of research go forward and that there be the closest liaison between the two groups.

Placing the civilian military research function in the proposed agency would bring it into close relationship with a broad program of basic research in both the natural sciences and medicine. A balance between military and other research could thus readily be maintained.

The establishment of the new agency, including a civilian military research group, should not be delayed by the existence of the Research Board for National Security, which is a temporary measure. Nor should the creation of the new agency be delayed by uncertainties in regard to the postwar organization of our military departments themselves. Clearly, the new agency, including a civilian military research group within it, can remain sufficiently flexible to adapt its operations to whatever may be the final organization of the military departments.

National Research Foundation.—It is my judgment that the national interest in scientific research and scientific education can best be promoted by the creation of a National Research Foundation.

I. *Purposes.*—The National Research Foundation should develop and promote a national policy for scientific research and scientific education, should support basic research in nonprofit organizations, should develop scientific talent in American youth by means of scholarships and fellowships, and should by contract and otherwise support long-range research on military matters.

II. *Members.*—1. Responsibility to the people, through the President and the Congress, should be placed in the hands of, say nine Members, who should be persons not otherwise connected with the Government and not representative of any special interest, who

should be known as National Research Foundation Members, selected by the President on the basis of their interest in and capacity to promote the purposes of the Foundation.

2. The terms of the Members should be, say, 4 years, and no Member should be eligible for immediate reappointment provided he has served a full 4-year term. It should be arranged that the Members first appointed serve terms of such length that at least two Members are appointed each succeeding year.

3. The Members should serve without compensation but should be entitled to their expenses incurred in the performance of their duties.

4. The Members should elect their own chairman annually.

5. The chief executive officer of the Foundation should be a director appointed by the Members. Subject to the direction and supervision of the Foundation Members (acting as a board), the director should discharge all the fiscal, legal, and administrative functions of the Foundation. The director should receive a salary that is fully adequate to attract an outstanding man to the post.

6. There should be an administrative office responsible to the director to handle in one place the fiscal, legal, personnel, and other similar administrative functions necessary to the accomplishment of the purposes of the Foundation.

7. With the exception of the director, the division members, and one executive officer appointed by the director to administer the affairs of each division, all employees of the Foundation should be appointed under Civil Service regulations.

III. *Organization.*—1. In order to accomplish the purposes of the Foundation the Members should establish several professional Divisions to be responsible to the Members. At the outset these Divisions should be:

a. Division of Medical Research.—The function of this Division should be to support medical research.

b. Division of Natural Sciences.—The function of this Division should be to support research in the physical and natural sciences.

c. Division of National Defense.—It should be the function of this Division to support long-range scientific research on military matters.

d. Division of Scientific Personnel and Education.—It should be the function of this Division to support and to supervise the grant of scholarships and fellowships in science.

e. Division of Publications and Scientific Collaboration.—This Division should be charged with encouraging the publication of scientific knowledge and promoting international exchange of scientific information.

2. Each Division of the Foundation should be made up of at least five members, appointed by the Members of the Foundation. In making such appointments the Members should request and consider recommendations from the National Academy of Sciences which should be asked to establish a new National Research Foundation nominating committee in order to bring together the recommendations of scientists in all organizations. The chairman of each Division should be appointed by the Members of the Foundation.

3. The division Members should be appointed for such terms as the Members of the Foundation may determine, and may be reappointed at the discretion of the Members. They should receive their expenses and compensation for their services at a per diem rate of, say, $50 while engaged on business of the Foundation, but no division member should receive more than, say, $10,000 compensation per year.

4. Membership of the Division of National Defense should include, in addition to, say, five civilian members, one representative designated by the Secretary of War, and one representative of the Secretary of the Navy, who should serve without additional compensation for this duty.

IV. *Functions.*—1. *The Members of the Foundation should have the following functions, powers, and duties:*

a. To formulate over-all policies of the Foundation.

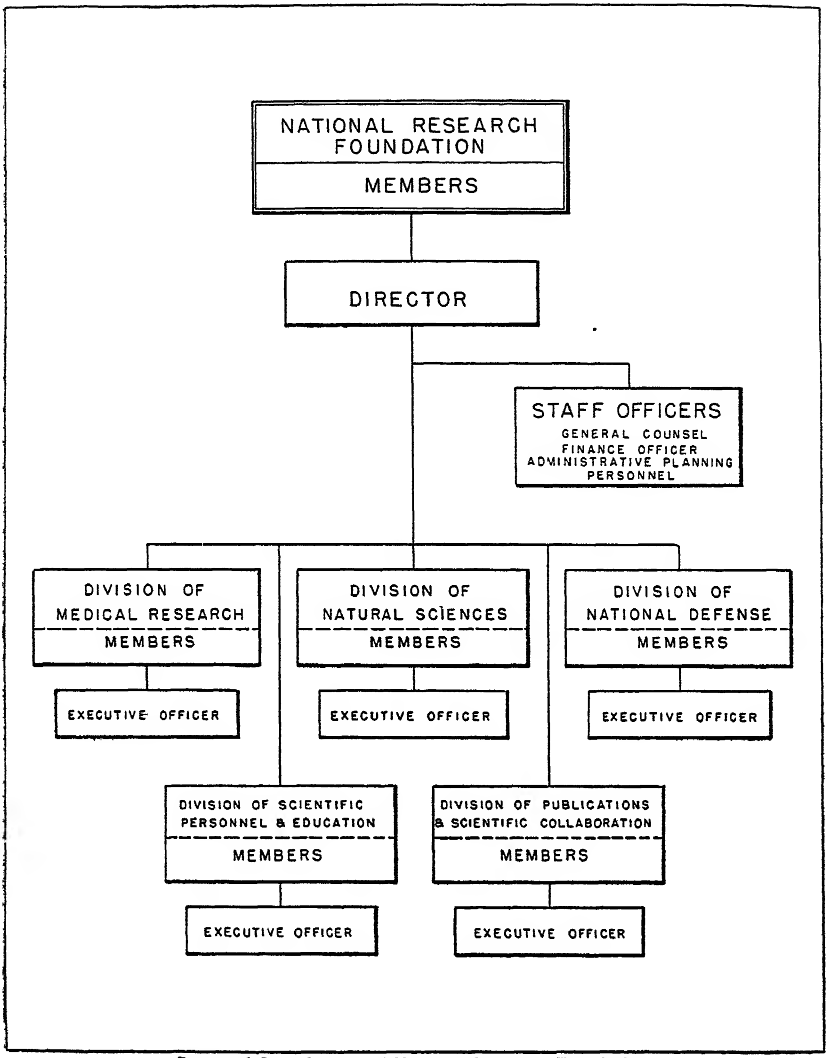
b. To establish and maintain such offices within the United States, its territories and possessions, as they may deem necessary.

c. To meet and function at any place within the United States, its territories and possessions.

d. To obtain and utilize the services of other Government agencies to the extent that such agencies are prepared to render such services.

e. To adopt, promulgate, amend, and rescind rules and regulations to carry out the provisions of the legislation and the policies and practices of the Foundation.

f. To review and balance the financial requirements of the several Divisions and to propose to the President the annual estimate for the funds required by each Division. Appropriations should be earmarked for the purposes of specific Divisions, but the Foun-



Proposed Organization of National Research Foundation

dation should be left discretion with respect to the expenditure of each Division's funds.

g. To make contracts or grants for the conduct of research by negotiation without advertising for bids.

And with the advice of the National Research Foundation Divisions concerned—

h. To create such advisory and cooperating agencies and councils, state, regional, or national, as in their judgment will aid in

effectuating the purposes of the legislation, and to pay the expenses thereof.

i. To enter into contracts with or make grants to educational and nonprofit research institutions for support of scientific research.

j. To initiate and finance in appropriate agencies, institutions, or organizations, research on problems related to the national defense.

k. To initiate and finance in appropriate organizations research projects for which existing facilities are unavailable or inadequate.

l. To establish scholarships and fellowships in the natural sciences including biology and medicine.

m. To promote the dissemination of scientific and technical information and to further its international exchange.

n. To support international cooperation in science by providing financial aid for international meetings, associations of scientific societies, and scientific research programs organized on an international basis.

o. To devise and promote the use of methods of improving the transition between research and its practical application in industry.

2. *The Divisions should be responsible to the Members of the Foundation for—*

a. Formulation of programs and policy within the scope of the particular Divisions.

b. Recommendation regarding the allocation of research programs among research organizations.

c. Recommendation of appropriate arrangements between the Foundation and the organizations selected to carry on the program.

d. Recommendation of arrangements with State and local authorities in regard to cooperation in a program of science scholarships and fellowships.

e. Periodic review of the quality of research being conducted under the auspices of the particular Division and revision of the program of support of research.

f. Presentation of budgets of financial needs for the work of the Division.

g. Maintaining liaison with other scientific research agencies, both governmental and private, concerned with the work of the Division.

V. *Patent Policy.*—The success of the National Research Foundation in promoting scientific research in this country will de-

pend to a very large degree upon the cooperation of organizations outside the Government. In making contracts with or grants to such organizations the Foundation should protect the public interest adequately and at the same time leave the cooperating organization with adequate freedom and incentive to conduct scientific research. The public interest will normally be adequately protected if the Government receives a royalty-free license for governmental purposes under any patents resulting from work financed by the Foundation. There should be no obligation on the research institution to patent discoveries made as a result of support from the Foundation. There should certainly *not* be any absolute requirement that all rights in such discoveries be assigned to the Government, but it should be left to the discretion of the director and the interested Division whether in special cases the public interest requires such an assignment. Legislation on this point should leave to the Members of the Foundation discretion as to its patent policy in order that patent arrangements may be adjusted as circumstances and the public interest require.

VI. *Special Authority.*—In order to insure that men of great competence and experience may be designated as Members of the Foundation and as members of the several professional Divisions, the legislation creating the Foundation should contain specific authorization so that the Members of the Foundation and the Members of the Divisions may also engage in private and gainful employment, notwithstanding the provisions of any other laws: provided, however, that no compensation for such employment is received in any form from any profit-making institution which receives funds under contract, or otherwise, from the Division or Divisions of the Foundation with which the individual is concerned. In normal times, in view of the restrictive statutory prohibitions against dual interests on the part of Government officials, it would be virtually impossible to persuade persons having private employment of any kind to serve the Government in an official capacity. In order, however, to secure the part-time services of the most competent men as Members of the Foundation and the Divisions, these stringent prohibitions should be relaxed to the extent indicated.

Since research is unlike the procurement of standardized items, which are susceptible to competitive bidding on fixed specifications, the legislation creating the National Research Foundation should free the Foundation from the obligation to place its contracts for research through advertising for bids. This is particularly so since

the measure of a successful research contract lies not in the dollar cost but in the qualitative and quantitative contribution which is made to our knowledge. The extent of this contribution in turn depends on the creative spirit and talent which can be brought to bear within a research laboratory. The National Research Foundation must, therefore, be free to place its research contracts or grants not only with those institutions which have a demonstrated research capacity but also with other institutions whose latent talent or creative atmosphere affords promise of research success.

As in the case of the research sponsored during the war by the Office of Scientific Research and Development, the research sponsored by the National Research Foundation should be conducted, in general, on an actual cost basis without profit to the institution receiving the research contract or grant.

There is one other matter which requires special mention. Since research does not fall within the category of normal commercial or procurement operations which are easily covered by the usual contractual relations, it is essential that certain statutory and regulatory fiscal requirements be waived in the case of research contractors. For example, the National Research Foundation should be authorized by legislation to make, modify, or amend contracts of all kinds with or without legal consideration, and without performance bonds. Similarly, advance payments should be allowed in the discretion of the Director of the Foundation when required. Finally, the normal vouchering requirements of the General Accounting Office with respect to detailed itemization or substantiation of vouchers submitted under cost contracts should be relaxed for research contractors. Adherence to the usual procedures in the case of research contracts will impair the efficiency of research operations and will needlessly increase the cost of the work to the Government. Without the broad authority along these lines which was contained in the First War Powers Act and its implementing Executive Orders, together with the special relaxation of vouchering requirements granted by the General Accounting Office, the Office of Scientific Research and Development would have been gravely handicapped in carrying on research on military matters during this war. Colleges and universities in which research will be conducted principally under contract with the Foundation are, unlike commercial institutions, not equipped to handle the detailed vouchering procedures and auditing technicalities which are required of the usual Government contractors.

VII. *Budget.*—Studies by the several committees provide a partial basis for making an estimate of the order of magnitude of the funds required to implement the proposed program. Clearly the program should grow in a healthy manner from modest beginnings. The following very rough estimates are given for the first year of operation after the Foundation is organized and operating, and for the fifth year of operation when it is expected that the operations would have reached a fairly stable level:

Activity	Millions of dollars First year	Millions of dollars Fifth year
Division of Medical Research	$5.0	$20.0
Division of Natural Sciences	10.0	50.0
Division of National Defense	10.0	20.0
Division of Scientific Personnel and Education	7.0	29.0
Division of Publications and Scientific Collaboration	.5	1.0
Administration	1.0	2.5
	33.5	122.5

Action by Congress.—The National Research Foundation herein proposed meets the urgent need of the days ahead. The form of the organization suggested is the result of considerable deliberation. The form is important. The very successful pattern of organization of the National Advisory Committee for Aeronautics, which has promoted basic research on problems of flight during the past thirty years, has been carefully considered in proposing the method of appointment of Members of the Foundation and in defining their responsibilities. Moreover, whatever program is established it is vitally important that it satisfy the Five Fundamentals.

The Foundation here proposed has been described only in outline. The excellent reports of the committees which studied these matters should be consulted. They will be of aid in furnishing detailed suggestions.

Legislation is necessary. It should be drafted with great care. Early action is imperative, however, if this nation is to meet the challenge of science and fully utilize the potentialities of science. On the wisdom with which we bring science to bear against the problems of the coming years depends in large measure our future as a nation.

The Editor's Page

Transactions
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ROBERT TAFT, *Editor*

The editor was greatly pleased with an unsolicited letter recently received from Dr. Robert B. Wylie of the University of Iowa commenting on the *Transactions*. As the concluding paragraph of Dr. Wylie's letter expresses neatly some of the ideas held by the editor in planning each quarterly issue, I quote the paragraph here:

> The section on "Scientific News and Notes" adds a personal touch and is both informative and stimulating. Most college activities (football, debating, competition for promising students, etc.) tend to separate and segregate the several institutions. Such spirit and feeling of rivalry is often carried through the lifetime of their alumni and is fostered by a mistaken belief that hostility to other schools is proof of continuing loyalty to "Alma Ma". Your publication is helping to integrate your membership with respect to their common obligations to state and region.

It is the editor's hope that the *Transactions* will fulfill the prediction made in Dr. Wylie's last sentence and he bespeaks the aid and cooperation of all Academy members in fulfilling it.

* * *

Vannevar Bush, the author of the exceedingly important report to President Truman which constitutes the feature article of this issue, is the son of a New England clergyman. Dr. Bush

DR. VANNEVAR BUSH

was born fifty-five years ago at Everett, a suburb of Boston "the home of the bean and the cod." The restricted conversations of the Cabots and Lowells who appear in the famous four-line rhyme—along with the bean and

the cod—are in no way related to those of Dr. Bush. Dr. Bush has spoken at some length to the whole civilized world. The scientific profession, the public, Congress, and, what is most amazing, even the Army have listened. Before the war, the name of Bush was known chiefly in the field of electrical engineering and even the scientific profession as a whole was unfamiliar with his name. A brief sketch of his rise to prominence may, therefore, be in order. Dr. Bush was graduated from Tufts College in 1913 and three years later was granted a doctorate in engineering by M.I.T. and Harvard University. He began a teaching career in 1914 at Tufts as instructor of mathematics but two years later he became assistant professor of electrical engineering. During the first World War he was engaged in problems of submarine detection by the U.S. Navy. At the close of the war, he became associate professor of power transmission at M.I.T. He was promoted to a professorship in 1923 and from 1932 to 1938 was vice president and dean of engineering at the Institute. One of his major professional accomplishments was the planning and construction of the differential analyser, a device for the solution of differential equations. In a recent number of the *Atlantic Monthly* (July, 1945) he suggests still another device, "the memex", a marvelous mechanical-electrical aid to the scholar's memory and even to his thinking.

In 1939, Dr. Bush became president of the Carnegie Institute of Washington and when World War II began, he was chosen to direct the affairs of the Office of Scientific Research and Development; its first and so far its only director. The most notable achievements of O.S.R.D. and its various branches include the now world-shaking atomic bomb project; work on the new superexplosive RDX; research on new metals and alloys for armament and for guns and jet engine construction; development of radar and of electrical gun directors; the development of penicillin; the production and use of blood plasma; and studies on the prevention and treatment of tropical diseases.

The complete report *Science—The Endless Frontier,* is 184 pages in length and includes not only Dr. Bush's report proper but as appendices there are included the reports of the four advisory committees as follows: "Report of the Medical Advisory Committee", Dr. W. W. Palmer, chairman, 19 pages; "Report of the Committee on Science and the Public Welfare", Dr. Isaiah Bowman, chairman, 57 pages; "Report of the Committee on Discovery and Development of Scientific Talent" by Mr. Henry Allen Moe, chairman, 43 pages; "Report of the Committee on Publication of Scientific Information", Dr. Irvin Stewart, chairman, 4 pages. Replete with statistics and estimates, these reports are extensive and important documents in their own right. The complete report may be secured for 30c by addressing the Supt. of Documents, Government Printing Office, Washington, D. C.

Extensive proposed legislation

in both houses of Congress has followed the Bush report. Senator Kilgore of West Virginia and Senator Magnuson of Washington both have introduced bills in the Senate and Congressmen Mills (Arkansas) and Randolph (West Virginia) have introduced bills in the House identical with that of Senator Magnuson. Both the Kilgore and Magnuson bills plan for the support of basic scientific and medical research as well as research for the national defense. Probably the greatest difference in the two bills lies in the two directive boards of the proposed national research organization. The Kilgore bill provides for a board more than half of whose members would be cabinet or government agency members; under the Magnuson bill, the board would consist of individuals selected on the basis of their knowledge, ability and capacity for the direction of scientific work, and without regard to the political affiliation of any member.

In addition to these bills, a number of others relating directly or indirectly to national research policies and aids have been introduced.* It is quite obvious then that Congress is now science conscious and there is hope—if hearings before Congressional committees are not too long protracted—that a national scientific policy will be formulated. The editor believes that the Magnuson bill, following closely the recommendations of Dr. Bush, should be adopted and urges members of the Academy who feel likewise to write Senators Reed and Capper and their individual congressmen urging them to support this bill.

* * *

We plan to publish as our feature article in the March issue "The Present Status of Vitamins in the Human Diet" which Dr. E. V. McCollum of Johns Hopkins University is now preparing for the *Transactions*. Dr. McCollum, an honorary member of the Academy, has, as all members of the Academy should know, devoted a lifetime to the study of human nutrition and has received world-wide recognition for his work on the relation of diet to growth and disease. The article should be of interest to a wide scientific audience.

* * *

One article in this issue should be carefully avoided if the reader is troubled when a herd of pink elephants with curly blue tails accompanies him as he walks down Main Street. Nevertheless we are glad to publish this paper for it is, as one competent critic has told the editor, an important one in its field. We are referring, of course, to the study of Mexican reptiles by Dr. Hobart M. Smith and Leonard E. Laufe (page 325). We are glad to publish this contribution not only for its own merit (which is, of course, the fundamental and only reason for publication) but because one of its co-authors, Dr. Smith, is a former Kansan who still maintains his interest in Kansas. We take this occasion to invite other Kansans now residing elsewhere to submit their research papers to the *Transactions*.

*In the period 1942-1945 there have been introduced eleven bills in Congress relating to encouragement of scientific and technological research.

The Four Freedoms of the Spirit

For happiness that will endure a man need have only four things, which are his anchors to windward in time of stress. Their possession assures him peace of mind, no matter what happens, how modest or untoward his circumstance, how apparently trivial or futile his accomplishment. Without them, no pinnacle of success can satisfy; once aware of them, he may profitably focus on them efforts that without that knowledge have been scattered through the confusion of a thousand ambitions. In gaining them he will gain all else. I have called them the four freedoms of the spirit. They are stability; serenity; eagerness; and unfoldment.

Stability, not security. Security has to do with the world outside, a matter of stocks and bonds and houses and jobs and success in doing. It is a passive thing, of static insulations, only as long as it endures. It is an uncertain thing, for it is dependent on a shifting outside world of circumstance, on which no man can count. Stability has to do with the world within.

Serenity. Not the static of withdrawn endurance, or of fatalistic resignation, but an inner impregnability.

Eagerness. The liveness of effort that cannot be denied to our most inconsequent activities.

Unfoldment. The uplifting assurance of growth, of movement, of progress. The confidence that a man is getting somewhere, that what he does has meaning and purpose. The very source of the eagerness that makes all life worth while.—STEWART EDWARD WHITE in *Anchors to Windward,* 1943.*

*These paragraphs from Mr. White's book are reproduced through the kind permission of E. P. Dutton and Co., Publishers, New York City.

Scientific News and Notes of Academy Interest

Items for this column are solicited from all Academy members. For inclusion in any given issue they should be in the editor's hands at least three weeks before our publication dates, namely the fifteenth of March, June, September and December.

A most interesting case of the far-reaching influence of the *Transactions* has recently come to light. Several years ago Mr. C. E. Pemberton, chief entomologist of the Hawaiian Sugar Planters' Association Experiment Station and a commissioner of the Territorial Board of Agriculture and Forestry of Hawaii discovered an abstract of the paper, "A preliminary report on the insects attacking bindweed with special reference to Kansas", by Dr. Roger C. Smith, published in these *Transactions,* volume 41, 1938, pages 183 to 191.

Mr. Pemberton's attention was directed to the statement that the common morning glory leaf miner (*Bedellia somnulentella* (Zell.)) was severely attacked in Kansas by a parasite, *Apanteles bedelliae* Vier., which prevented the host from doing much damage to bindweed. Sweet potatoes in Hawaii are severely damaged, sometimes almost entirely defoliated, by the sweet-potato leaf miner, (*Bedellia Orchilella* Wlsm.) Immediately Mr. Pemberton called the attention of Mr. D. T. Fullaway, chief territorial entomologist of the Board of Agriculture, to the article who sent for a reprint. Together they evolved the plan to import the bindweed parasites from Kansas to Hawaii to determine whether the sweet potato leaf miner would be accepted by the parasite as a host and perhaps effectively control it.

Accordingly, Mr. Noel Krauss, associate entomologist of the Board, came to Manhattan in mid-July, 1945, and soon collected large numbers of the parasite cocoons which he sent to Hawaii by air express. The adults emerged promptly, and in the laboratory, accepted the sweet-potato leaf miner as a host. Mr. Krauss has sent possibly 2500 cocoons to Hawaii. At this writing there is every reason to believe the parasite will attack the sweet potato leaf miner in the field when large numbers of them are released.

The Hawaiian incident mentioned above shows the importance of the abstract and index journals in our present scheme of transmitting scientific information. It is doubtful if the information in Dr. Smith's paper would have reached Mr. Pemberton save through the medium of the abstract journal. The editor has recognized this fact and as a result, each issue of the *Transactions* is sent to all abstract and index journals in all scientific fields. At present there are about 15 such journals on our mailing list both at home and abroad. In addition we have recently received notice that we have been placed on the list of periodicals indexed in *International Index;* further, all articles

containing bibliographies (which include practically all of our professional papers) will be indexed in *Bibliographic Index*.

Permission has been requested and gladly granted in recent weeks to reprint two articles appearing in the *Transactions* during the past year. The Bureau of Governmental Research has requested permission to reprint Dr. Stene's article "The Development of Kansas Wildlife Conservation Policies." The Bureau plans on publishing the article in pamphlet form for distribution to county clerks in Kansas with the request that a copy be given to each applicant for fish and game licenses.

The article on perennial wheat by Messrs. Reitz, Johnston, and Anderson of Manhattan which appeared in our September issue is to be reprinted in *The Northwestern Miller* of Minneapolis.

Dr. Donald F. Hoffmeister, assistant curator of modern vertebrates, University of Kansas Museum, made a three-weeks collecting trip in central and western Kansas late in the past summer. Accompanying Dr. Hoffmeister in the field were Mr. Bernardo Villa and Mr. James Case. Pertinent information on the western limits of range of some species of mammals and the eastern limits of range of other species of mammals was especially sought. The principal area of collecting was the Arkansas River Valley.

Professor E. E. List, formerly of Shurtleff College, Alton, Illinois, has been appointed head of the biology department of Ottawa University succeeding Dr. S. M. Pady. Professor List has done graduate work at Washington University and the Universities of Chicago, Iowa and Michigan.

Dr. Otto Treitel, formerly of Fisk University, Nashville, Tennessee, is now engaged in research at the University of Pennsylvania in the laboratory of Dr. William Seifriz, professor of botany.

The Kansas Agricultural Experiment Station, to continue our series begun several issues ago on research centers in this area, is an institution of long standing in the state. The central controlling station is located at Manhattan and branch stations are located at Hays, Colby, Garden City and Tribune. In addition there are 13 experiment fields on rented farms located chiefly in the eastern part of the state.

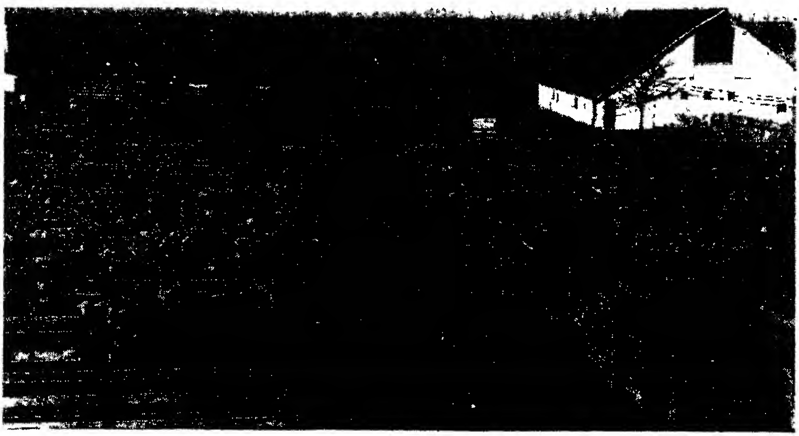
The experiment station was authorized by an act of the Congress of the United States, the terms of which were accepted by the Kansas Legislature on March 4, 1887. At the same time, the Legislature vested the responsibility for carrying out the provisions of the act of Congress with the Board of Regents of Kansas State College of Agriculture and Applied Science. The experiment station is both a state and a federal agency, and receives support from both state and federal sources.

The experiment station as a research agency is organized into 16 departments, the names of which indicate in a general way

the areas of research covered by the station:

Agricultural Economics
Agricultural Engineering
Agronomy (Soils and Crops)
Animal Husbandry
Bacteriology
Botany
Chemistry
Chemical Engineering
Dairy Husbandry
Entomology
Home Economics
Horticulture
Milling Industry
Poultry Husbandry
Veterinary Medicine
Zoology

The station employs 144 scientists and research workers who at the present time are applying themselves to more than 123 research and experimental projects. These projects cover practically all phases of experimental work in the field of agriculture. During the war, major emphasis was given to project work that would be specially valuable to the war effort. For example, at the outbreak of the war there came to light a need for starch to replace the root starches that formerly were imported from the East Indies. The station already had developed through breeding and selection the seed stocks of a strain of grain sorghum of the type needed to produce this starch. During the war the station and its cooperating farmers made good progress in the actual field production of this variety of sorghum for the manufacture of starch.



KANSAS AGRICULTURAL EXPERIMENT STATION.—Feeding experiments with sheep and lambs at the Garden City feed lots.

Now that the war has ended, the resources and the energies of the Agricultural Experiment Station will be turned to the agricultural problems of the post-war period, many of which will be no less serious than the problems of war time.

Much of the station work is planned and carried out in co-operation with the United States Department of Agriculture, and also with other state agricultural experiment stations. The station cooperates with the Kansas Industrial Development Commission in investigations affecting the industrial uses of agricultural products. Further, many commercial agencies call upon the agricultural experiment station for assistance in helping them solve problems that may contribute to the welfare of agriculture. Twenty-five such projects are now under way.

Persons interested in the projects under investigation at the station have access to the Twelfth Biennial Report of the Director (1942-1944). Those who desire information in any particular field on any agricultural subject may obtain such information through the medium of bulletins, technical bulletins and circulars that are available from the office of the director. A circular that lists all publications available at this time can be obtained by addressing L. E. Call, director of the Agricultural Experiment Station.

During the past two years alone the station has published 239 technical papers; 5 technical bulletins; 22 general bulletins; and 13 circulars.

The Navy V-12 unit was discontinued at Washburn Municipal University in October of this year. Cadet nurses are still on the campus.

The drill crew of the State Geological Survey of Kansas and the U. S. Geological Survey has recently completed drilling 26 test holes in the alluvium of the Elm Creek valley near Medicine Lodge. The work, an investigation to determine the chemical quality and possible contamination of the ground water in the Medicine Lodge area, was done by the two geological surveys in co-operation with the division of sanitation, Kansas State Board of Health. Elm Creek valley is a potential source of water supply for the city of Medicine Lodge, and knowledge of the chemical quality of the water together with information concerning the effect that present methods of oil field brine disposal may have on the ground water must be obtained before the water resources of the area can be developed safely. The drilling of 32 test holes for Hutchinson's proposed soft water system was also supervised by the State and Federal Geological Surveys.

Dr. Robert Taft, editor of these *Transactions*, was recently re-elected for a three-year term to the board of directors of the Kansas State Historical Society, Topeka.

Dr. Charles F. Swingle, a graduate of Kansas State College, Manhattan, has recently been appointed horticulturist at the Experiment Station, Tingo Maria, Peru.

An A.C. network analyzer has been purchased by the University of Kansas and the K. U. Research Foundation and will be used under the direction of

Dr. V. P. Hessler, chairman of the department of electrical engineering. The device, whose delivery is expected in March, will make possible the simulation in miniature of the electrical circuits of the most complicated power systems. The use of the instrument will be offered as a service to power companies and consulting engineering firms on a fee basis. Although intended primarily for power system studies, the instrument may also be used for the solution of mechanical stress problems, the study of the transmission of sound, of high frequency waves, and of flow of heat and water. Similar devices west of the Mississippi River are located at the Armour Research Foundation, Chicago, and at Bonneville Dam, Ampere, Washington.

The department of physics and astronomy at Washburn University, Topeka, has resumed "Observatory evenings" which were discontinued during the time of the large Navy enrollment in that department. The first "open house" was held Friday evening, October 16.

The Ecology of the Prairie Chicken in Missouri by Charles W. Schwartz has recently been published by the University of Missouri. This useful monograph deals with the distribution, the population, and the habits of the prairie chicken, including a comprehensive account of the peculiar behavior of these birds—the booming seasons. Discussion is made of the management practices favorable to the propagation and growth of this game bird. The monograph contains 99 pages of text including 12 text figures and a bibliography; an appendix consisting of 32 excellent photographs by the author (as can be seen from the sample illustration on the following page) and a second appendix consisting of 8 maps. The study upon which this monograph is based, is part of the Federal Aid-Wildlife Program of the Missouri Conservation Committee which has under way similar studies for each major native game and furbearing species in the state and which are directed by university-trained specialists. The question naturally arises why Kansas is so backward in making similar surveys. The head of the departments of zoology at both the University of Kansas and Kansas State College, Manhattan, would welcome the direction of such studies but the initiative must come apparently from the Kansas forestry, fish and game commission.

Mr. Schwartz is also the author of *The Prairie Chicken in Missouri* (published in 1944) which is essentially a pictorial record and is intended as a contribution toward popular interest in wildlife conservation. The illustrations in this popular guide are not duplicates, save for a few exceptions, of those in the ecological monograph. *The Ecology of the Prairie Chicken in Missouri* can be obtained for $1.50 per copy by addressing The Mailing Room, University of Missouri, Columbia.

A Survey of Game and Furbearing Animals of Oklahoma,

THE PRAIRIE CHICKEN.—Cock fully moulted, photographed in Morgan County, Missouri October 29, 1943. Courtesy Charles W. Schwartz and reproduced from his "Ecology of the Prairie Chicken in Missouri."

published this fall by the Oklahoma Game and Fish Commission, is another important book in the field of wildlife conservation in another neighbor state. The book of 144 pages contains fifteen chapters and a bibliography, 16 charts, 16 maps and 67 photographs. The purpose of the *Survey* was to make an adequate inventory of the wildlife resources of Oklahoma to serve as a basis upon which the Game and Fish Commission could form its policies.

It is a pleasure to report that most of the recommendations of the *Survey* have, on the whole, already been adopted by the Commission. The *Survey* was prepared for publication by Mr. L. G. Duck, director, division of wildlife restoration and research, and Mr. Jack B. Fisher, biologist. Among the game animals considered are two types of quail, the wild turkey, the prairie grouse, the American woodcock, squirrels, rabbits and the whitetail deer. A considerable discussion is also made of the Oklahoma fur trade with detailed facts and figures on the take of mink, opossum, muskrat, civet, badger, coyote and bobcat. The Oklahoma Game and Fish Commission is to be congratulated on its progressiveness in undertaking this survey and for making the results of the survey available to the public. Copies of this interesting book may be secured by addressing the Commission at Oklahoma City.

Professor W. C. McNown, professor of civil engineering at the University of Kansas, has published this fall a brief report on "Stabilized Earth for Use in Low Cost Housing." The report describes the production and use of soil-cement building blocks. Such blocks were used in the construction of the Engineering Experiment Station Building on the University campus some three years ago. Professor McNown reports that "We are satisfied with the performance of the blocks." Copies of the report and of an earlier bulletin *Soil-Cement Building Blocks* may be obtained by addressing the School of Engineering, University of Kansas, Lawrence.

Mr. Richard H. Zinszer is now district production engineer for the Union Oil Company at their Santa Maria field, California. The field is becoming so important in the production of petroleum that training of personnel is offered in a night school at the Santa Maria Union High School. Mr. Zinszer is offering a course in elementary oil reservoir study in the training program.

Mr. W. K. Zinszer has recently become ceramic engineer for Gladding, McBean and Company, one of the large producers of brick, tile, pottery and refractories on the Pacific Coast. Mr. Zinszer is located at the Pittsburg, California, plant, which specializes in the production of fire brick and other clay refractories. The Zinszer brothers are sons of Dr. Harvey A. Zinszer, former president of the Academy and professor of physics and astronomy at Fort Hays Kansas State College.

Mr. Russell R. Camp, formerly chief preparator in the Pea-

body Museum, Yale University, has accepted an appointment as preparator in vertebrate paleontology in the University of Kansas museum. Mr. Camp began his duties at the University on July 1.

Dr. Hobart Smith is serving during the current semester as assistant professor of zoology and assistant curator in herpetology at the University of Kansas. Dr. Smith is temporarily replacing Dr. E. H. Taylor, who is on leave of absence and serving overseas as civilian adviser to the United States Army.

Mr. Leonard E. Laufe, coauthor of the article on Mexican reptiles in this issue is now a member of the department of zoology, University of Pittsburgh, Pittsburgh, Pa.

Lt. (jg) Elmer Joe Hanks, formerly of Fort Hays, Kansas State College, is now stationed on the U.S.S. *Alpine* in the Pacific.

Capt. Albert W. Grundmann, formerly of the department of entomology, Kansas State College, Manhattan, is with the 402nd Malaria Survey Detachment of the U.S.A. in the South Pacific. Capt. Grundmann has been overseas for two and a half years.

Mrs. Clena Ingram Gibson, formerly of Kansas State Teachers College, Emporia, is now vocational adviser in the employ of the Veterans Administration, Little Rock, Arkansas.

Disposition of Oil Field Brines by Ogden S. Jones, geologist for the oil field section, division of sanitation, Kansas State Board of Health, was published by the Board during the past fall. The book contains 192 pages, 14 photographs, 7 diagrams, 10 appendices, and a table of contents but no index. As the title indicates, the book deals with important problems arising from salt waters encountered in drilling for oil-producing wells. The resulting brines constitute a possible menace to health by pollution of usable fresh water, and by producing adverse effects on fauna and flora of contiguous regions. The solution of these problems is discussed in the text and the appendices give legal and technical data bearing on the subject. Copies may be secured by addressing the author, Marvin Hall, University of Kansas, Lawrence.

Dr. Ralph E. Silker, assistant professor of chemistry, Kansas State College, Manhattan, has resigned his position to direct the research program and supervise the five control laboratories of the W. J. Small Company, Inc., Neodesha, Kansas. Dr. Silker will have his office, however, in the Fairfax district of Kansas City, Kansas. The W. J. Small Company are important producers of dehydrated alfalfa.

Mr. C. Howard Westman, for eight years a member of the museum staff of the University of Michigan, has been appointed taxidermist for Dyche Museum of Natural History and began his duties in October. Mr. Westman

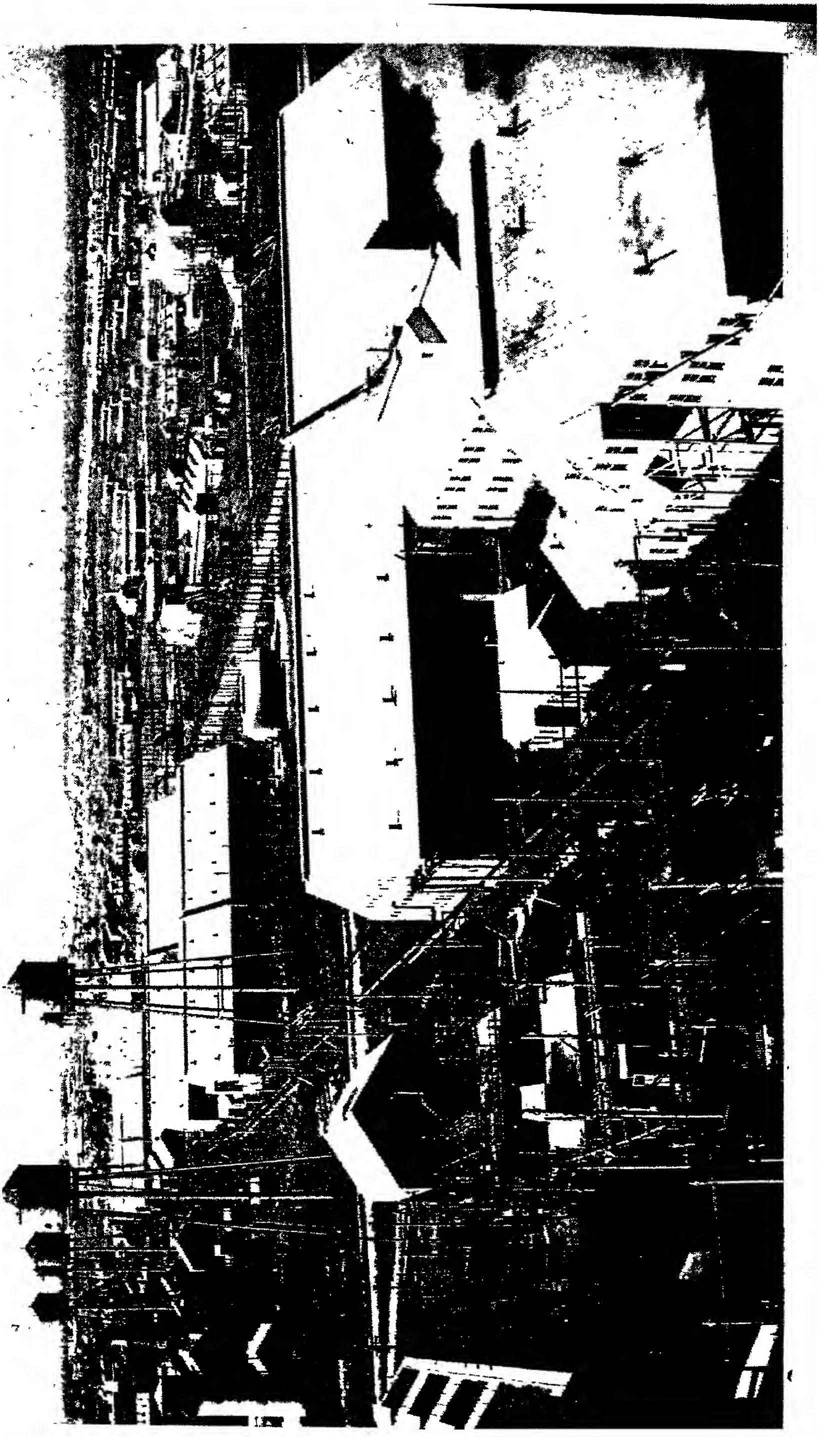
is a graduate of the University of Iowa and of the University of Michigan.

Dr. Phil Hambleton, of Topeka, was one of the chief investigators in the development of the electronic fuse known as V T. Dr. Hambleton was graduated from Washburn University in 1931 and took his master's degree from the University of Kansas a short time later. He received his doctor's degree from Johns Hopkins University in 1941 and was teaching there when he began work on the fuse.

Dr. John Breukelman, Emporia, president of the Academy and Dr. D. J. Ameel, Academy secretary, were both visitors at the University of Kansas during the fall. Each spent the larger part of a day examining the exhibits in Dyche Museum and conferring with members of the zoology department.

A University of Kansas Museum party consisting of Walt Dalquest, Vernon Mahon, Russell Camp and Dr. Claude W. Hibbard, spent November 1st to 5th in excavating and removing the skull and tusks of a Columbian Mammoth from a sand and gravel pit on the farm of Bernard Kennedy, nine miles south and two miles east of Soldier, Jackson County, Kansas. The specimen was found by Mr. Joe Kennedy and was reported by Mr. Bradley, a contractor of Holton, Kansas, who recognized the importance of the find. The Kennedy Brothers stopped their own work in the pit and helped in every way possible to preserve the specimen for scientific study. The skull and tusks are now encased in plaster and are being allowed to dry slowly in Dyche Museum. It is hoped that the complete recovery of the specimen can be accomplished. Ivory tusks, however, are among the most difficult specimens to preserve as they tend to disintegrate rapidly when removed from the mother matrix. Complete recovery would give the Kansas Museum its only specimens of mammoth tusks.

One of the major war industries of Kansas was the Sunflower Ordnance Works located some twelve or fourteen miles east of Lawrence. Viewed at night from Mount Oread at Lawrence, the glow from the plant resembled the lights of a great city. Over 4500 buildings were scattered over an area of approximately 15 square miles and the production facilities of Sunflower required a water supply system equivalent to those of both Kansas City, Missouri, and Kansas City, Kansas. More than 175,000,000 pounds of rocket, artillery, and small arms powder were produced since the first production line started operation on March 24, 1943, a production used by our own army and navy and by Russia. Since that date, the production lines have grown to eight in number and facilities for manufacturing sulfuric and nitric acids, nitroglycerin, nitrocellulose and oleum have been added. At peak production, from January 1, 1945, to August 14, 1945, twelve thousand workers were required to staff the largest rocket pow-



der producing plant in the United States at the close of World War II.

Construction of the Sunflower Plant, government owned, was started May 8, 1942, five months after the Japanese attack on Pearl Harbor, by the architectural firm of William S. Lozier, Inc., of Rochester, New York, and the construction company of W. S. Broderick and D. G. Gordon of Denver, Colorado, under the supervision of the United States Army Corps of Engineers. The principal operating contract of the plant was carried out by the Hercules Powder Company of Wilmington, Delaware.

Sunflower is still in operation but on December 1, employees totaled some 3100 and much of the plant was being put in standby condition. Its future use—whether for peace or war or for rust and decay—today remains uncertain.

As the editor viewed the illustration on the opposite page of this giant industry of war, an industry on the rolling prairies of eastern Kansas, he could not help but compare it with a description and estimate of the same region in its primeval state written nearly a century ago, and marvel at the change. If the reader is interested in the comparison, he should turn to page 285.

Dr. G. Baly Price, professor of mathematics at the University of Kansas, has recently returned from a leave of absence beginning in November, 1943. From this date to May 8, 1945, he was a member of the bombing accuracy subsection of the Operations Analysis Section, Eighth Air Force, and stationed at Air Force Headquarters in England. The Section with which Dr. Price was connected made studies of bombing results for the purpose of improving performance in combat and for planning future operations. When the war ended, Dr. Price was on his way to Guam to do similar work with the Twentieth Air Force.

Dr. D. C. Brodie has been appointed associate professor of pharmaceutical chemistry at the University of Kansas. Dr. Brodie received his doctorate from Purdue University in February, 1944, and since then has been engaged in war research at the University of Rochester, Rochester, N. Y.

New assistant instructors in chemistry at the University of Kansas include: Mr. Richard Bidle, Eastern Illinois State Teachers College; Mr. Harold Smith, Lewis and Clark College, Portland, Oregon; Mr. Owen Sprague, University of Michigan; Mr. Stephen Stephanou, Massachusetts Institute of Technology. Mr. Leon Bradlow, University of Pennsylvania, has been appointed research assistant with the University of Kansas Research Foundation.

◄ Part of the manufacturing area of S.O.W. showing some of the equipment and the thousands of buildings used in producing rocket, artillery and small arms powder which aided in eventually bringing Germany and Japan to their knees.—(U.S. Army Photo, Courtesy Sunflower Ordnance Works.)

Dr. Harold C. Choguill, now a member of the U. S. Navy, has been appointed associate professor of chemistry at Fort Hays Kansas State College. He will begin his duties in the near future upon his release from the Navy. Dr. Choguill, who received his doctorate from the University of Kansas, was formerly a member of the teaching staff of Independence Junior College before he joined the Armed Services in 1943.

Mr. M. S. Dendurent, a graduate of Kansas State College, Manhattan, is serving as acting instructor in chemistry at the University of Kansas City. Mr. Dendurent is replacing Dr. Franklin Lewis who died suddenly several months ago.

Dr. Ethan P. Allen, formerly of the U. S. Bureau of the Budget, has been appointed director of the Bureau of Governmental Research at the University of Kansas. Dr. Allen is a graduate of the University of Colorado and of Iowa State University.

Scientific Societies in the United States by Ralph S. Bates of the Massachusetts Institute of Technology (John Wiley and Sons, N.Y., $3.50, 246 pp.), published during the current year, gives an amazingly compact view of the history and influence of a great variety of scientific societies in the United States. National, state, municipal and local societies have been included; within the scope of the term "science" one finds not only "pure" science but natural history in its various forms, medicine, engineering, dentistry, agriculture, etc. Coincident with the main theme of the book, are running comments on individuals who have organized many of these societies and who have played leading parts in the development of American scientific thought. A very useful bibliography is also included.

The following list of dates of the formation of state academies of science still in existence has been compiled chiefly from data in Professor Bates' book:

Connecticut	1799
New York	1817
California	1853
Maryland	1863
Kansas	1868
Wisconsin	1870
Indiana	1885
Iowa	1887
Nebraska	1891
Ohio	1891
Michigan	1894
Montana	1901
North Carolina	1902
North Dakota	1908
Utah	1908*
Oklahoma	1909*
Tennessee	1912
Kentucky	1914*
New Hampshire	1919
Georgia	1922
Virginia	1923
Washington	1923
Pennsylvania	1924
West Virginia	1924
Alabama	1924
South Carolina	1924*
Colorado-Wyoming	1927
Louisiana	1927
Texas	1928
Mississippi	1931*
Minnesota	1932
Missouri	1934
Florida	1935
Nevada	1941
Oregon	1943

The exact title of these academies varies somewhat and probably, as Professor Bates points

*Starred values have been taken from the report of "The Academy Conference" A.A.A.S., September 11, 1944.

out, there are equivalent societies in states not appearing in the above list. We are prone to look upon state academies as among the relicts of early science but, surprisingly enough, over two-thirds of the organizations listed above have been formed since 1900 and nearly one half since 1919. It is a matter of pride to see Kansas among the oldest of state academies. Although not the first western state academy of science, it is the second; but it was the first state academy organized in the vast region between the Mississippi River and the Pacific coast.

The geological exhibits at William Jewell College are being classified and re-arranged by Dr. L. J. Gier. The exhibits include the extensive collections of Dr. H. M. Richmond, professor of natural science at William Jewell from 1892 to 1908.

Dr. and Mrs. Charles E. Burt of the Quivera Specialties Company, Topeka, will spend a month in Mexico during the winter collecting biological and other natural history specimens for the Company.

The Menninger Foundation School of Psychiatry, Topeka, will begin on January first a three-year course in theoretical and practical psychiatry. Clinical work in the School will be conducted at Winter General Hospital and the Menninger Psychiatric Hospital. It is expected that twenty or twenty-five civilian doctors — mostly discharged service veterans — will enroll for the beginning term.

Drs. W. H. Schoewe, J. M. Jewett and G. Abernathy of the State Geological Survey of Kansas represented the State Geological Survey at the Sixth Annual Oklahoma Mineral Industries Conference held at Ada, Oklahoma on November 29, 30 and December 1. The conference included an all-day tour to pits, quarries and undeveloped deposits of a variety of industrial minerals of high quality, and to one of the state's important oil and gas fields.

The Quest of American Life by George Norlin (University of Colorado Studies, 1945, 280 pp.) is recommended as a book to be read by all members of the scientific profession. The late Dr. Norlin, president of the University of Colorado from 1917 to 1939, was a native Kansan for he was born in Concordia, Kansas, in 1871, and received much of his education in the Great Plains region. A distinguished scholar and one of the great college and university presidents of the West, Dr. Norlin, in this volume, published posthumously, endeavors to trace the development of humanism in American history by considering the life and work of its chief protagonists. Considering his background, it is not surprising that Dr. Norlin views the westward movement as one of the chief causes in the development of humanism in America.

Although humanism is usually regarded as the self-adopted cult of students of the so-called humanities, there is no fundamental reason for any such restriction. Science is a part of humanism

and students of science should be as interested in this field as are students of the humanities, especially if one adopts as the definition of humanism the memorable one given by Dr. Norlin. "Humanism . . . denotes," writes Dr. Norlin, "an attitude of mind and heart which holds to the preciousness of human life, which has faith in the potential dignity and worth of our human being apart from the trappings of wealth or station, and which strives to create a social soil and climate wherein every human personality may take root and flower and be fruitful, each in accordance with the nature and capacity of each." The concluding essay in the volume "East Versus West" will be of especial interest to all who, like the editor, are regionally conscious. The volume can be obtained at a cost of $2.00 by addressing the Editor, University of Colorado Studies, Boulder.

During the past November, Dr. John C. Frye, assistant state geologist accompanied Mr. George S. Knapp, chief engineer, division of water resources, State Board of Agriculture, on an inspection tour of dam sites in northwestern Kansas, including the Pony Basin, Kirwin and Kanopolis sites.

Exploration for Oil and Gas in Western Kansas During 1944, Walter A. Ver Wiebe (State Geological Survey of Kansas, Bulletin 56, 112 pages, December, 1945) discusses the results of some 1508 test holes drilled in western Kansas during 1944. 666 of the test holes resulted in producing oil wells and 98 in producing gas wells. 53 new oil or gas pools were discovered, the most important at present being the Adell pool in Sheridan County, the Coats pool in Pratt County and the Pritchard pool in Barton County. Kiowa and Stanton Counties were added to the list of oil and gas-producing counties in Kansas. Western Kansas in 1944 produced the major portion of the natural gas of the state, 127 billion cubic feet out of a total annual production of 134 billion cubic feet—the greatest annual production in Kansas on record—coming from this region. Copies of Bulletin 56 may be secured from the Survey at Lawrence, Kansas, for a mailing charge of 25 cents.

Dr. T. E. White spent a week in October studying at the University of Kansas Museum while home on terminal leave after returning from the African and Italian theaters of war. He has now returned to the Museum of Comparative Anatomy at Harvard University to resume his duties as assistant curator of vertebrate paleontology.

Capt. William R. Taylor, formerly of the U. S. Air Corps, has returned to civilian life and is now enrolled as a student in the University of Kansas.

Lt. George C. Rinker has returned from Europe and has been in Lawrence on furlough the past month doing special work on Kansas vertebrates at the University of Kansas Museum. He will return to the University of Kansas as a grad-

uate student in zoology as soon as he receives his discharge.

Honorary Academy member George Wagner, emeritus professor of zoology, University of Wisconsin writes "I wish to extend congratulations on the new form of the *Transactions* and on the continued high quality of its contents. I look over every number with great interest." Professor Wagner, for forty years a member of the zoology department at Wisconsin, now lives in Palo Alto, California.

Another kind word concerning the *Transactions* comes from Dr. Loren C. Eiseley, formerly of the University of Kansas, but now chairman of the department of sociology, Oberlin College, Ohio. Dr. Eiseley writes "I am glad to continue my membership for I find the *Transactions* most interesting."

Atomic Energy for Military Purposes by Henry DeWolf Smyth (Princeton University Press, 1945, 264 pages, paper bound $1.25, cloth bound, $2.00)* summarizes officially much of the enormous enterprise and work leading up to the production of the atomic bomb. After an elementary introduction to the subject of nuclear physics, the scientific, technological, and administrative history of release of energy by atomic fission in the period 1939 to 1945 is discussed. The problem of the atomic bomb reduced to its simplest terms consisted of finding and producing elementary substances which would, when bombarded with slow neutrons, give fission products (i.e., smaller atomic fragments than the original atom) and at the same time release energy and a greater number of neutrons than used initially. As more neutrons were released these acted upon remaining nuclei thus producing fission products and energy at an ever increasing rate until explosive violence was attained. The elementary substances useful for this purpose were found to be U-235 and Pu-239 (plutonium), both of which are derived from ordinary uranium ores.* The means of producing or separating, purifying and controlling these products under conditions non-hazardous to the workers employed in their production constitute the main portion of the book. A chapter is also devoted to the trial atomic bomb explosion in New Mexico. Photographic illustrations include views of the plants at Oak Ridge, Tennessee, and Hanford, Washington, and of the test atomic bomb explosion in New Mexico.

No description, of course, is given of the mechanism of the bomb proper. Some idea of the enormous amount of fundamental scientific work done in these completely government-financed operations is the statement that "thirty volumes will be required

*This book is a slightly enlarged and modified revision of *A General Account of the Development of Methods of Using Atomic Energy for Military Purposes*, by H. D. Smyth, Government Printing Office, Washington, 1945, 182 pages, 35 cents. No photographic illustrations. The same report is reprinted in *Reviews of Modern Physics*, October, 1945, also without photographic illustrations.

*The report states "If all the atoms in a kilogram of U-235 undergo fission the energy released is equivalent to the energy released in the explosion of about 20,000 short tons of TNT."

for a complete report of the significant scientific results of researches" conducted by one division of the project alone.

Dr. Ray H. Beaton, formerly a member of the chemical section of the atomic bomb project at Oak Ridge, Tennessee, and Washington, has been appointed associate professor of chemical engineering at the University of Kansas. Dr. Beaton, who will begin his duties at Kansas on January 1st, is a graduate of Northwestern University and received his doctorate from Yale University in 1942.

Mr. Philip J. Potter, formerly of Bucknell University, Lewisburg, Pennsylvania, has been appointed associate professor of mechanical engineering at the University of Kansas. Mr. Potter, a graduate of Illinois and Pennsylvania Universities, in addition to teaching experience at Bucknell and at Swarthmore College, was for eight years in the employ of the Philadelphia Electric Company.

Dr. James O. Maloney, formerly a member of the Dupont organization at Wilmington, Delaware, has been appointed director of the University of Kansas Research Foundation and chairman of the department of chemical engineering at the University. Dr. Maloney, a graduate of Illinois University, and with a doctorate from Pennsylvania State College in 1941, began his duties at Kansas on December 1st.

The managing editor of the *Transactions* will soon begin a membership campaign among the science teachers in the 700 high schools of Kansas and the aid of Academy members in encouraging the campaign is earnestly requested. We already have a number of high school science teachers on our membership list but we should have many more. Some of these members have themselves been active in the affairs of the Academy and have interested themselves in calling the attention of their colleagues to the advantages of Academy membership. Mr. Blaine E. Sites of Salina High School, for example, brought the matter up at one of the recent sectional meetings of the Kansas State Teachers Association and secured a number of memberships. Similar cooperation from other teacher members would be greatly appreciated.

Dr. James C. Coleman was appointed this fall to an instructorship in psychology at the University of Kansas and will specialize in the field of social and abnormal psychology. Dr. Coleman received his doctorate from the University of California at Los Angeles in 1942 and since that time has served as instructor at U.C.L.A. and as personnel consultant for the Douglas Aircraft Corporation.

"Such Is Kansas and Nebraska"*

Our opening scene is a birds eye view of that wide extended region lying between the Missouri river, and the summits of the Sierra Nevada Mountains of California,—Comprising in its limits portions of Nebraska, Kansas, and Oregon Territories and the Whole of Utah. Leaving the Missouri, we travel over rolling plains; graduly and almost impreceptably attaining a high altitude, to the Eastren base of the Rocky Mountains. Some distance from the Messouri and especially along the margin of its tributaries A considerable degree of fertility obtains. The rolling prairies are covered with rank grasses, ornate through the vernal season with the most brilliant wild flowers far as the eye extends there is a succession of rolling hills singularly regular in form, as though a mighty welling ocean had been suddenly Congealed. The timber is entirely confined to the immediate margin of the streams termed in the West "bottoms." These, are so deeply indented that even the loftiest trees fringing the banks break not upon the genial horizan. The traveller precieves them not until immediately upon them. The trees are few and small, consisting of a few species the walnut, the hickory oak, and a kind of Cotton Wood peculiar to the Plains, and soon the latter only remain to cheer and comfort the traveller.

The streams are tributaries to the Kansas, and great Missouri and though dignified with the names of Rivers are simply drains for the surplus water falling in the prairies, Fluctuating by the vissiccitudes of the weather A storm arrises and in a few hours they roll a turbid and angry flood, inundating the "bottoms" and sweeping all before them In as short a period the floods have passed away, and in the heat of summer, the traveller wanders along their arrid beds looking in vein for water, to sustain himself and animels

Every days journey marks a gradual assimilation to the desert wastes which skirt the base of the distant Mountains. The Grasses upon the hills become thin, short, and finally almost disappear, Vegitation for the sustanence of animels is confined to the "bottoms" and the traveller must perforce journay along the margins of the great rivers, Such is Nebraska and Kansas, fit only for the homes of the wantering tribes to whom it has been hitherto devoted by nature, and our government. Without navigable streams or important mineral resourses, Nothing but Earth and Air, Without timber to fence or build upon the one, and fuel to protect from the inclemencies and viscisitudes of the other. The stern necessities of an overburdened population Enhancing the value of Lands in all other parts of the Country beyond the means of the Masses may possibly at some future day render it profitable to import Every thing necessary to build up civilization and a strip about one hundred miles in width may become dotted over with habitations of tillers of the soil Beyond this portion the utmost necessities of humanity, Can never render it any thing but a home for Nomadic Tribes who can readily move from point to point where vegitation is found to sustain their herds

Should these Territories now be organized they will doubtless be a gathering into them of those restless border spirits who have ever been fleeing before the advanceing strides of civilization, and are now hanging restlessly on the Extreme Westren Limits of Missouri and Iowa with guns and dogs ready for the chase, and withering ponderous anathana on their tongues against churches School houses, and Courts of Justice.—J. Wesley Jones, 1853.

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*This eloquent description, though oddly punctuated, and still more oddly spelled, was written by one J. Wesley Jones, as part of a lecture presented with a huge panoramic painting of the Westward Journey in the days of '49. Jones gave his lecture in many of the cities of the east in the early 1850's. A literal transcript of his lecture notes, from which the above paragraphs were taken, will be found in the *Calif. Hist. Soc. Quart.*, vol. 6, page 111 (1929). For the Kansas prairies of 1945, see page 278.

A Survey of the Fossil Vertebrates of Kansas

H. H. LANE
University of Kansas, Lawrence.

PART II: AMPHIBIA*

Superclass Tetrapoda

In contrast to the fishes with their paired fins, all those vertebrates which have legs to support the body and for locomotion are grouped together in the *Superclass Tetrapoda.* Typically, there are two pairs of these appendages, the anterior or *pectoral* pair of limbs, corresponding to man's arms, and the posterior or *pelvic* pair, corresponding to man's legs. However, in some cases, the anterior pair may be modified into wings for flight, as has happened in three known cases among the tetrapods; or, the two pairs may be reduced to one, usually the anterior. In some snakes vestiges of the hind pair may be found, with no trace of the front pair; in a few other snakes vestiges of the front pair may be present, although the hind pair may have been entirely lost. In most snakes, however, as well as in some lizards and a few amphibians, both living and fossil, both pairs of limbs have been lost. Generally speaking, the normal habitat of the tetrapods is the land; however, some, *e.g.,* the whales among the mammals and certain reptiles, have returned to live in the water and have transformed their pentadactyl limbs into flippers for swimming; and, of course, many amphibians, as well, are wholly aquatic.

The transformation from fish to amphibian was of more fundamental importance than most other changes which the vertebrates have undergone. Compared with it, changes from fresh to salt water, or from terrestrial to arboreal or volant habit, are insignificant. But although the amphibians succeeded in making this momentous change, on the whole they have never been successful in mastering the land. They have never been able to emancipate themselves from the water—and fresh water at that—except in the case of a few exceptional species. In most instances their eggs must be laid in water; their young are larvae ("tadpoles" or "pollywogs") that must have water in which to live, feed and grow. Even the

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*For Part I of this Survey (The Fishes) see these *Transactions,* volume 47, pp. 129-176 (1944). Part I also contains a time chart of rocks exposed in Kansas, the classification of vertebrates, and a glossary of geological and biological terms.

adults must, in general, keep near the water or at least damp situations in order to keep from drying out and mummifying. In the water, however, the amphibians are at a disadvantage in competition with most fishes; and on land they are unable to overcome their handicaps in competition with their own offspring, the reptiles. So, crowded out of the water and barely able to maintain themselves on shore, they have never played a conspicuously successful rôle in vertebrate life.

CLASS AMPHIBIA

The *Amphibia* constitute a class of tetrapods that is, on the one hand, very closely allied in structure and mode of life with the fishes, and, on the other hand, has such a marked superficial resemblance to the reptiles that few persons not professional zoölogists distinguish between them. However, the fact is that in many respects the frog, for example, is far more highly specialized than most living reptiles, other than the snakes. The name *"Amphibia"* is from the Greek *"amphibios"*, signifying "double life", in allusion to their most distinctive characteristic, namely, a true "metamorphosis", or change of form, that occurs when the larva becomes like the adult, except in size. Their young are typically wholly aquatic, respiring by means of gills and propelling themselves through the water by means of a large compressed tail. At first, the tadpole has no more resemblance to its parents than a maggot has to a fly, or a caterpillar to a moth. Later, but gradually, the tadpole grows legs, resorbs (*not loses*) its tail and gills, develops lungs and nostrils, replaces its temporary larval mouth with the "true" mouth of an adult, and becomes a land-living form, such as a toad or frog.

Arising, in so far as now known, in the Upper Devonian of Greenland, the *Amphibia* underwent their greatest changes in form during the Mississippian, Pennsylvanian and Permian times, although one order, the labyrinthodonts, did not reach their zenith until the Triassic. The *Class Amphibia* includes eight orders of which three are wholly extinct, while the others all have living representatives. They are "cold-blooded", or, more accurately speaking, their body-temperature varies with that of their surroundings since they have no physiological mechanism for its control. In the living amphibians, with the exception of the *Apoda,* the skin is totally devoid of scutes, scales or plates, but many of the extinct forms had dermal scutes or bony plates more or less covering the body. The living *Apoda* have peculiar scales buried in the skin, either on the

ventral side of the body only, or all over, as in the Mexican genus *Siphonops.*†

Different amphibians are aquatic or terrestrial, some even fossorial, and breath by means of gills or lungs, or the skin of the general body-surface, depending upon the habits and structure of the species under consideration. The heart consists of three chambers, two auricles and one ventricle. The skull in living amphibians (and in many of the extinct forms as well) articulates with the back-bone by means of two articular surfaces (*condyles*), but in many of the earlier extinct forms this articulation involves a single structure—sometimes, however, with clear indications of a division into three parts—one median and two lateral, the last represented by the condyles in modern amphibians. The pelvic girdle ("hip-bones") is attached to the back-bone by means of a single pair of sacral ribs. The appendages of the amphibians may be adapted to walking, crawling, leaping, climbing, or swimming; more rarely they may be reduced or absent.

OUTLINE CLASSIFICATION OF THE AMPHIBIA

PHYLUM CHORDATA
- SUBPHYLUM VERTEBRATA (=CRANIATA)
  - SUPERCLASS TETRAPODA
    - Class AMPHIBIA
      - Subclass I. STEGOCEPHALIA
        - Order 1. *Ichthyostegalia**
        - Order 2. *Lepospondyli**
        - Order 3. *Labyrinthodontia**
          - Suborder a. Embolomeri*
          - Suborder b. Rhachitomi*
          - Suborder c. Stereospondyli*
        - Order 4. *Apoda* (=*Caecelia*=*Gymnophiona*)
      - Subclass II. CAUDATA (=URODELA)
        - Order 5. *Proteida*
        - Order 6. *Mutabilia*
        - Order 7. *Meantes*
      - Subclass III. SALIENTIA
        - Order 8. *Anura*
          - Suborder a. Amphicoela
          - Suborder b. Opisthocoela

†Personal communication from Senor Professor Manuel Maldonado-Koerdell, Polytechnic Institute, Mexico.

*Entirely extinct.

Suborder c. Anomocoela
Suborder d. Procoela
Suborder e. Diplasiocoela.

Subclass I. Stegocephalia

The *Subclass Stegocephalia* comprises four orders, of which three are entirely extinct; the fourth living, with no certainly known fossil representatives. In form the members of this subclass generally resemble a modern salamander, or an alligator, with the tail often more or less adapted for swimming, *i.e.,* flattened from side to side (*compressed*). The skull consists of a solid "roof" of bones, perforated only by the nasal openings, the orbits of the eyes, and the parietal foramen—the last to accommodate a *third* eye that was located on the top of the skull in the median line slightly back of the paired eyes. This is absent in the living *Apoda.* The skull surface is frequently sculptured and also marked with grooves for the lateral line system of sense-organs. The teeth are usually conical and sharp-pointed, mostly with a large pulp-cavity, and with simple or complex, radially arranged folds of dentine and enamel, which finally are so complex as to deserve the appellation of "labyrinthine". The origin of this type of tooth structure may be seen among the early crossopterygian fishes (see pages 150-152, Part I, of this survey, Dec., 1944); later stages also occur in these fishes, but the climax is reached only in the amphibian order of *Labyrinthodontia.* The bodies (*centra*) of the stegocephalian vertebrae are varied in form and structure, and constitute the basis for the determination of the several orders and suborders as given in the table of classification (p. 288). On the throat and "chest" (*thoracic*) region there are generally three externally sculptured bony plates forming the ventral part of the shoulder (*pectoral*) girdle. In contrast to the other subclasses of amphibians, the *Stegocephalia,* as a rule, possess a well-developed dermal skeleton consisting of ossified scutes, scales, or rods, especially on the ventral side of the body, but sometimes covering the under sides of the legs as well; in a few cases similar structures are also more or less well-developed on the dorsal side of the body. The ventral scales or rods are generally arranged in oblique rows, and vary extremely in form.

Order 1. Ichthyostegalia

The earliest amphibians at present known are two genera (*Ichthyostega* and *Ichthyostegopsis*) from the Upper Devonian of

Greenland. These genera are so primitive that they must be set off from all known later members of the class in an order to themselves, called the *Ichthyostegelia.* They are surprisingly large for early amphibians, the skulls alone being six inches or more in length—high and narrow after the manner of most fishes, instead of broad and flat as in most later amphibians. Every bone, except one, occurs in these skulls that has been found in the skulls of the higher tetrapods, and in addition there is the noteworthy persistence of the *preopercular*—the last remnant of the gill-cover of the fishes—as well as a *rostral* bone on the front end of the snout. Still another crossopterygian reminiscence is found in the location of the *external nares* (nostrils) on the *under* side of the head and separated from the *internal nares* by a slender bar of bone only. However, the lower jaw has extended forward enough to cover the internal nares, while leaving the external exposed. Any statements concerning the habitat and habits of these, the oldest amphibians, would be purely conjectural, but it is clear that the climate of Greenland in the Upper Devonian was far different from that to be found there now. Certainly, instead of "icy mountains" Greenland then must have been a land of semi-tropical climate and "coral strands"; and as such it continued until a much later date in the history of the earth.

ORDER 2. LEPOSPONDYLI

The *Order Lepospondyli* is made up of small amphibians, at first rather like the modern salamanders in form, with a rather long body and tail, moderately developed legs, and a skull of normal amphibian proportions, *i.e., broad and very flat.* However, divergence in these characters arose at a very early date, and even degenerative changes appeared, such as the loss of limbs and the development of a greatly elongated eel-like body, indicating a completely *aquatic* life. In general, when present, the hind limbs are longer than the front ones; the *pubes* are ossified, a condition rarely found in amphibians elsewhere except among the early labyrinthodonts. Furthermore, many of them have elements of the wrist (*carpus*) and ankle (*tarsus*) also fully ossified—another condition rarely found among the amphibians. The teeth are simple and conical with large pulp cavities, but no infoldings of dentine and enamel are found. The ventral surface of the body is protected by an armor of oval scales.

The *Lepospondyli* are so called because of the shape of their vertebrae, which have the form of constricted cylinders, enclosing the continuous notochord. They are frequently compared to a spool or

an hour-glass in shape. The neural arches rest upon the centra, either sitting loosely, or united by a suture, or sometimes even firmly coössified with them.

This order, chiefly of small-sized creatures, was on this account formerly called the "Microsauria". It reached its peak in numbers and variety in Pennsylvanian time, when its members outnumbered all other amphibians combined. It was a relatively short-lived group, for there were but three known survivors in the earliest Permian, and not one in later time. The oldest known lepospondylids are from the upper Mississippian, yet, because of the high degree of specialization which had even then been attained, it is evident that they must have arisen much earlier. Apparently the only lepospondylid yet found in Kansas is an undetermined species of nectridian—possibly belonging to the genus *Sauropleura*, or to one closely related to that genus—from the Rock Lake shale of Anderson County.

The second line of nectridians included creatures with small legs, a broad flat body, and a bizarre plowshare-shaped skull with its postero-lateral angles produced into horn-like projections. *Diplocaulus* (Fig. 1) of the Lower Permian was the culmination of this line of aberrant development. Its body was two feet or more in length and almost as broad as long. Its legs were not only disproportionally small but they were attached well within the lateral borders of the body and probably took small part in locomotion. While *Diplocaulus* is known only from Texas and Oklahoma, in the latter state it occurs so close to the Kansas state-line, that there can be little doubt that it actually lived in this state. Its head as a whole was so large and massive and had so much heavy bone in it that it could not have been lifted from the ground *on land*. Only in the water could this misfit creature have moved at all, as is clearly indicated by its broad body and long, flattened tail. Its teeth, small, delicate and conical, suggest a diet of soft animal or plant materials. It was thus a highly specialized animal that had departed widely from its ancestral type and had become degenerate.

Order 3. Labyrinthodontia

The *Labyrinthodontia* are so named on account of their most striking feature—*the structure of their teeth,* in which the infolding of the enamel and dentine into the pulp cavity follows such an extremely tortuous course that a cross-section of a tooth (Fig. 2) reveals a complicated pattern that is truly *labyrinthine*. This order of amphibians is made up of heavy, clumsy animals with heads long,

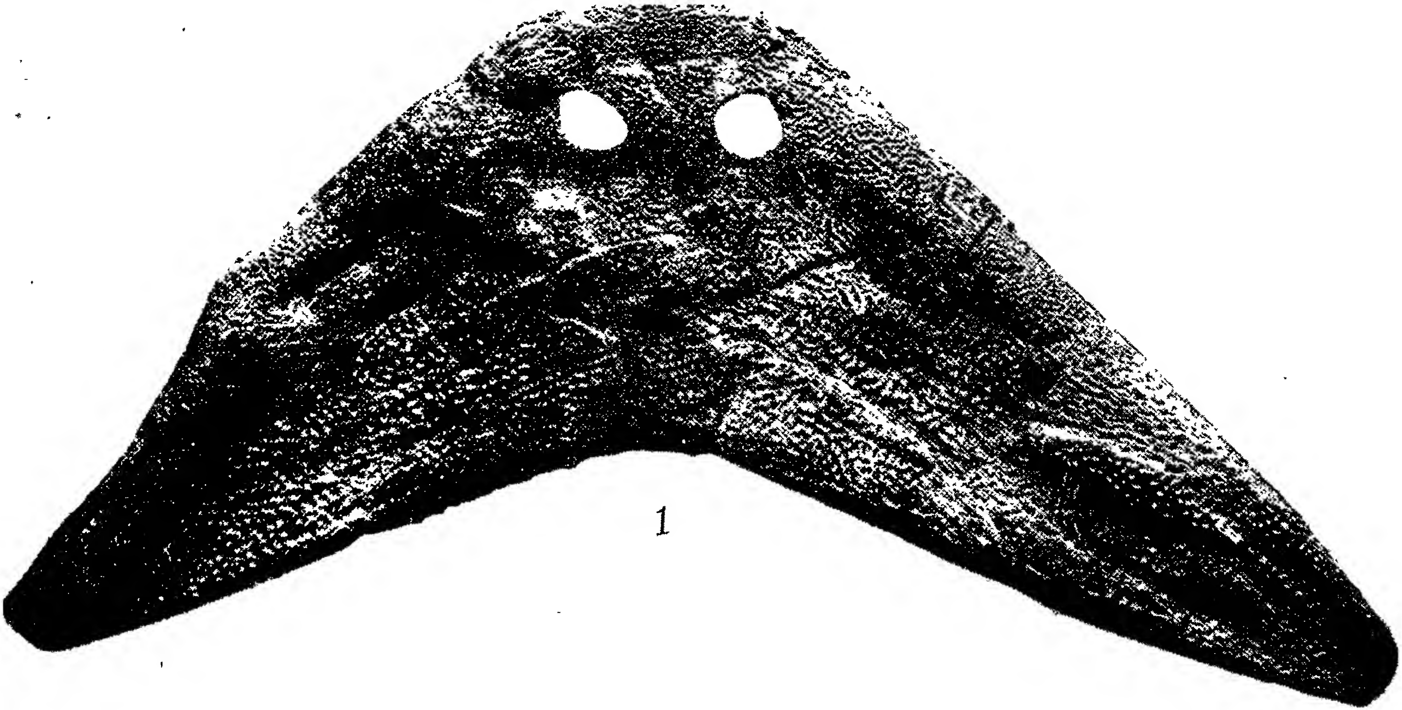

FIG. 1. Skull of Diplocaulus magnicornis, from Roy L. Moodie in Journal of Morphology, Vol. 23, No. 1, March, 1912, plate 1. One half natural size.

wide and flat; bodies broad and very stout; tails generally short. The thighs and upper arms are attached at right angles to the body so that the latter is suspended as in a sling, resulting in a slow,

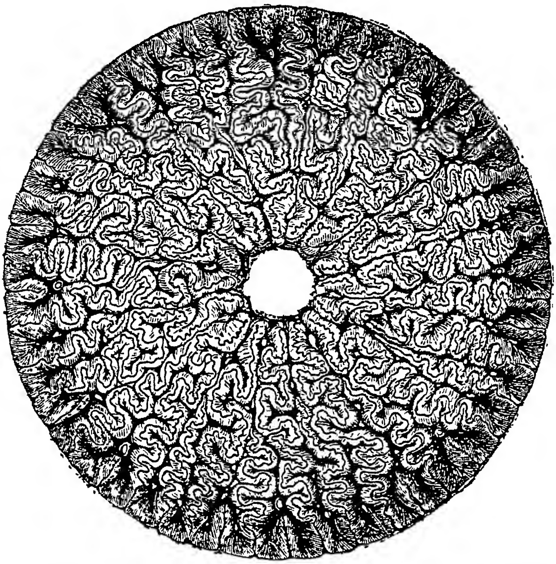

FIG. 2. Cross-section of a tooth of Mastodonsaurus to show the structure of a labyrinthodont tooth. From Owen. Enlarged.

awkward, waddling gait. All but one of them known have but *four* fingers on the hand, though all have *five* toes on the foot. They include practically all the larger amphibians of the late Mississippian, Pennsylvanian, Permian and Triassic times. Relatively few in the Carboniferous, fairly common in the Permian, they attain their maximum in size, number and variety of form in the Triassic, during which time they spread to all the continents, except possibly South America.

The more generalized of the labyrinthodonts were certainly ancestral to the earliest reptiles, which greatly resemble them, and yet they are structurally not far removed from the earliest tetrapods. On the other hand, they were in part prophetic types, for as Gregory has shown and as Romer points out, "almost every skeletal element of a bird or of a man may be traced back to these primitive types. Later forms have greatly modified the shape and relationships of parts and there have been frequent losses of bones, but the fundamental pattern laid down in the early tetrapods still persists."

Three suborders of the *Labyrinthodontia* are usually recog-

nized—the distinctions being based upon the structure of their vertebrae and other parts—namely, the *Embolomeri,* the *Rhachitomi,* and the *Stereospondyli.*

"PHYLLOSPONDYLI"

In paleontological textbooks and journals a supposedly early "order" of amphibians has been widely recognized under the name of the *"Phyllospondyli"*. A recent study of these forms by Romer, however, has demonstrated that as an *order* the Phyllospondyli do not exist. The Branchiosouria and other forms heretofore assigned to it are simply small and immature (*i.e.,* larval) labyrinthodonts belonging to the suborders *Embolomeri* and *Rhachitomi.* The typical branchiosaurs are small, *imperfectly ossified.* short-headed, and in many cases *certainly gill-bearing.* These features in themselves indicate larval stages. Even Credner's monograph on the branchiosaurs is replete with evidence that supports Romer's conclusion. We therefore give no place to the *"Order Phyllospondyli"* in our table of classification.

SUBORDER A. EMBOLOMERI

The *Embolomeri* are very primitive amphibians common in the Upper Paleozoic swamps, from two feet in length up to a size comparable to that of a modern alligator. In general proportions they are somewhat like modern salamanders, though the body is proportionally higher and more rounded. Apparently more aquatic than otherwise, they probably fed on the small palaeoniscid fishes (see Part I of this survey, pages 152-153) of their time, as well as on one another. In the many details of structure and mode of life they were still much like the ancestral crossopterygian fishes. The most obvious difference lies in their possession of legs instead of fins. Remnants of the old fish scales were still present, but confined to the ventral side of the body in V-shaped rows. The most ancient *Embolomeri* occur in the Mississippian, and had their head joined to the anterior end of the backbone by means of a *single* occipital condyle. The neck was short, with only four or five vertebrae; the trunk was long and cylindrical, supported by a series of vertebrae, whose bodies were composed of two rings of bone, threaded like beads on the persistent notochord (Fig. 3). The ribs were double-headed and were borne on neck, trunk and tail vetebrae. The tail was long and laterally flattened, so that it evidently was an efficient organ of locomotion.

The structure of the vertebrae just described is called "embolomerous", from the Greek, meaning "cut in two parts", the first of which, called the *intercentrum,* is intercalated between the adjacent *pleuracentra.* The well-developed *neural* arches, and, in the tail region, the *haemal* arches as well, rest upon the intercentra (Fig. 3).

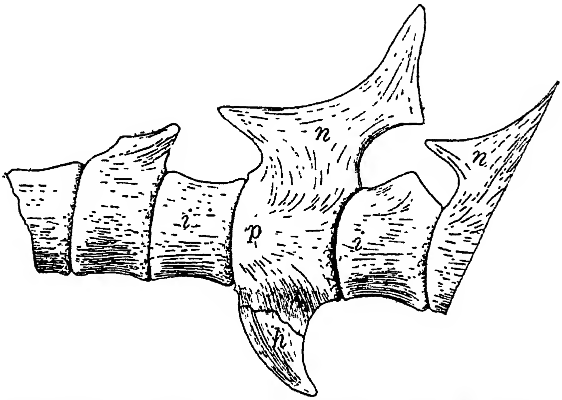

FIG. 3. Embolomerous vertebrae of Spondylerpeton, from Moodie in K. U. Science Bulletin, Vol. VI, No. 2, Jan., 1912, plate 9, figure 1. Natural size.
n, neural arch; i, intercentrum; p, pleurocentrum.

The neural arches, in turn, bear special articular processes called *zygapophyses.* On the *anterior* end of the vertebra these zygapophyses consist of a pair of rounded articular surfaces which face upwards to meet the *posterior* pair on the vertebra next anterior, which face downwards. Between the *ilia,* or dorsal elements of the pelvis, there is a *single pair* of enlarged *sacral ribs* with which the ilia articulate. This arrangement permits better support of the body-weight on the hind legs, as well as giving the latter a more substantial part in the forward propulsion of the animal in locomotion.

The dorsal surface of the skull is covered with dermal bones, recalling the condition in the crossopterygian fishes, and still has, in addition to orbits for the usual pair of eyes, an opening on the top of the head for the *third* eye, which was commonly present in all the early amphibians. In the strictly aquatic embolomeres the old piscine *lateral line* system of sense organs was still retained, forming grooves over and under the eyes and elsewhere on the lower jaw and rear portion of the skull.

The first embolomere recorded from Kansas belongs to the genus *Cricotus,* an incompletely known form with an elongated body and short, sturdy limbs. The long triangular skull has a reduced

snout; the *large,* oval eyesockets are located at about the middle of the length of the skull. The dermal bones roofing over the head are weakly sculptured, and carry grooves for the accommodation of the lateral line canals. The embolomerous vertebrae are disk-shaped in the caudal region, but anterior to the sacrum the pleuracentra and intercentra are horseshoe-shaped, the pleuracentra alone bearing the neural arches and the ribs; in the caudal region the neural arches are jointly supported by one each of these two elements, while the haemal arches are borne exclusively by the intercentra. The abdominal plates are rhomboidal in shape, closely packed in V-shaped rows.

Cricotus occurs from Illinois southwestward through Kansas and Oklahoma into Texas. It is obviously a fish-eating type with sharp-pointed conical teeth that varied in size in different parts of the jaws. Its skull articulates with the backbone by means of a single condyle only. *Cricotus heteroclitus,* the largest species, is about ten feet long. It was first described by Cope in 1884 from the Upper Pennsylvanian deposits on Salt Creek, in Illinois. Williston described a specimen from the Upper Pennsylvanian of Cowley County, Kansas, in 1897.

Suborder B. Rhachitomi

This suborder of the labyrinthodonts occurs from the Upper Pennsylvanian to the Lower Triassic. Its members are very large forms, especially those in the Permian and the few survivals in the Triassic. The name indicates their most striking characteristic, namely, the "dissected" condition of the vertebral centra, due to the failure of the large ventral wedge-shaped intercentrum to fuse with the paired lateral pleuracentra (Fig. 4). In the skull, the palatal vacuities are medium to large; the occipital condyles, double or triple.

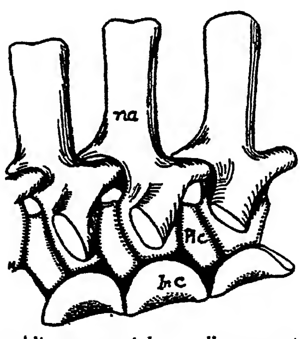

FIG. 4. Rhachitomous vertebrae: diagrammatic. Original. na, neural arch; Ic, intercentrum; Pl C, pleurocentrum.

Of the dozen or more known families of rhachitomes, only one has so far yielded a representative in Kansas. This is the genus *Eryops* of the Permian, which was among the largest forms of its suborder; in fact, it is one of the largest amphibians of any sort that ever lived in America, reaching a length of eight feet or more, while its body and limbs are massive. Its skull in some specimens is more than two feet long and up to eighteen inches broad across its posterior end, and is somewhat depressed. The bones of the skull are both tuberculated and pitted. The sutures and the parietal foramen usually disappear with age. The relatively small eyes lie just back of the middle of the length of the skull. The external nares are large. The teeth in the jaws are conical and rather small; a pair of larger teeth are located on the *palatine* and *prevomer*. The *parasphenoid* bone on the base of the skull is broad and dagger-shaped. The ribs are notable for the presence of *uncinate processes*. Contrary to the general habit of amphibians, *Eryops* has *five* toes on *both* the front and hind feet; although one on the front foot is vestigal. The limbs are short and powerful, such as would be needed by an animal that spent most of its time on land, even though near the water into which it could plunge for an occasional wetting of its

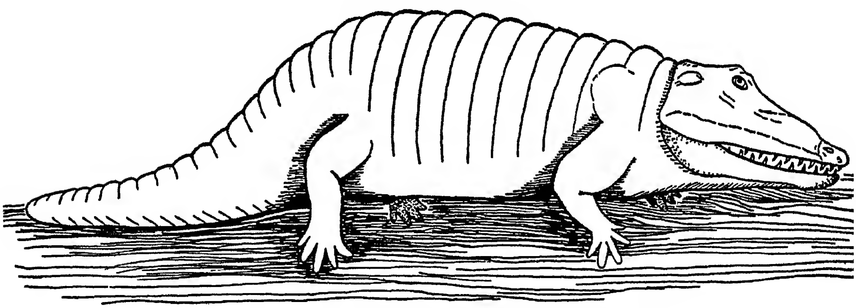

FIG 5. Restoration of Eryops. Original. 1/24th natural size.

skin. Its shoulder girdle does not articulate with the skull; the pelvis, on the other hand, is united with the vertebral column through a single sacral rib on each side.

Eryops was collected in "the red-beds of Kansas" (Cowley County) by the late Dr. S. W. Williston in 1899; the species was identified as *Eryops megacephalus*.

Suborder C. Stereospondyli

The *Stereospondyli* are the largest, the last and the most specialized labyrinthodonts, sometimes with a head three to four feet

long. The skull is much flattened and the paired eyes look directly upward, indicating a bottom-dwelling habit. Since the lower jaw articulates with the skull well back of the occipital condyles, as in modern crocodiles, the gape is enormous, and it may be, as some maintain, that they "opened the mouth by lifting the upper part of the head while the jaw rested on the mud". Their many teeth are sharp-pointed and conical, and two at the front of the jaw are so long in some species that they pass through openings in the upper jaws in front of the nostrils, actually protruding from the top of the skull when the mouth is closed. The body and tail are short, though the trunk is broad and flat. The ventral side of the pectoral ("chest") region is protected by a broad breast-plate composed of three bones —a pair of *clavicles* ("collar-bones") and an *interclavicle*—upon which is borne the weight of the anterior part of the body while at rest.

Although confined mostly to Triassic time, nevertheless the stereospondylids became common the world around, and some of them apparently even became *marine*. No other amphibian, ancient or modern, is known to be able to withstand the toxic effects of sea water for any appreciable length of time. Two genera of *Stereospondyli* have been recorded from Kansas. The first was described in 1897 by Dr. S. W. Williston from the "Coal Measures" (? Manhattan limestone) near Louisville, Pottawatomie County, Kansas. The specimen was collected by Herbert Bailey and consists of a single tooth with some associated bone fragments. Williston compared this tooth with those of *Mastodonsaurus* from the Triassic of Germany, and was unable to detect any differences between this Upper Pennsylvanian tooth and those of the Old World Triassic form, so he assigned it (KUMVP No. 457) to that genus, but refrained from giving it specific designation. *Mastodonsaurus,* as might be inferred from the name, was probably the largest of all the labyrinthodonts. Its skull is about four feet long, subtriangular in shape, with very large openings for the eyes lying just back of the middle of the skull length. Two additional openings in the premaxillary bones, anterior to the nostrils, accommodate a pair of very long teeth in the lower jaw.

The most extreme development of labyrinthine teeth known distinguishes this genus (Fig. 2). In the smaller paleozoic stegocephalians the teeth are small slender cones with large pulp cavities. In later genera the lower half or two-thirds of the length of the tooth is externally furrowed or ribbed, and the dentine is in folds to

an equal height, radiating inward toward the pulp cavity. In *Mastodonsaurus* the radiating folds of dentine and enamel follow tortuous courses, some extending only partially, others completely through the substance of the tooth, and convert it into a literal labyrinth when observed in cross-section.

The second stereospondylid from Kansas was described by Moodie in 1911 under the name of *Erpetosuchus kansensis.* This species is represented in the United States National Museum by a fragment of a skull, portions of two ribs, and the larger part of the left half of the lower jaw, 305 mm. long (USNMVP, Cat. No's. 6680 and 6699). These fragments are labelled as from the "Coal Measures, Washington County, Kansas", and very likely came from the eastern edge of that county near the bank of the Little Blue River, or a tributary of the same. Although *Erpetosuchus* was originally referred to the "Coal Measures", there is yet the possibility that it actually came from the *Lower Permian,* for no actual Pennsylvanian outcrops are known to occur in Washington County, though they seem to be present in adjacent Marshall County, near Marysville.

ORDER 4. APODA

The systematic position of this order has not been a stable one. It has been regarded as the most highly specialized of all living amphibians. Some authorities have included it among the CAUDATA close to the Amphiumidae (See p. 288). Others have placed it at the bottom of the line of living amphibians as an independent order not closely related to any other. But recently the conclusion has been advanced that the Apoda represent a highly specialized but degenerate group of stegocephalians closely related to the Lepospondyli.

Whatever the final decision may be, it is clear that the Apoda at present constitute an order of legless, burrowing amphibians of tropical or subtropical distribution. The group comprises over fifty species living in South America, Central America, Mexico, Africa, India and Ceylon. They are wormlike in appearance, with short tails or none at all. Superficially their skin is smooth and naked, but buried within it are many peculiar scales, either covering the whole body (*Siphonops mexicana*) or limited to the ventral side. *This is the only occurrence of scales in living amphibians.* Although not exceeding ten inches in length, the backbone may be made up of no less than 250 vertebrae. The whole order is clearly a highly specialized and degenerate one; their eyes are vestigial, but the tactile

sense is evidently keen; a retractile *tentacle* lies in a groove below, or in front of, each eye and it functions as a special organ of touch.

No apodan is known from Kansas, either living or fossil.

Subclass II. Caudata (=*Urodela*)

The *Subclass Caudata* comprises a large number of species which have an elongated body and tail, in some instances so long as to be eel-like or snake-like in proportions. They have either two or four legs of nearly equal size, *i.e.,* with the hind pair *not* enlarged for leaping. They include both primitive and specialized forms. Some are wholly aquatic throughout life; others leave the water after passing through the larval ("tadpole") stage and become terrestrial. The changes in the tadpole as it becomes adult are, in most instances, not very great, while in others they amount to a real metamorphosis. Some retain their external gills throughout life, even in cases where *functional lungs* are also developed, as in the mud-puppy (*Necturus maculosus*). The waterdogs and newts have the tail compressed (*i.e.,* flattened from side to side) to function as the chief organ of propulsion in swimming. The terrestrial salamanders have a rounded tail and resorb their gills as they become adults; in others the gills atrophy although the gill-slits may remain open; others dispense with both gills and lungs, and the soft moist skin of the body functions as a respiratory organ.

The *Caudata* have received a variety of popular names, such as salamander, mudpuppy, waterdog, hellbender, newt, evet and eft. By many they are mistakenly called "lizards", because some of them look a bit like such *reptiles,* from which they are easily distinguished by the absence of scales. Moreover, the terrestrial caudates live only under stones, rotten logs, and in damp situations generally, never in hot, dry habitats where lizards abound.

The caudate skull is generally notable for the *absence* of many bones well-developed in the stegocephalians, particularly in the brain-case (*cranium*) which is largely cartilaginous. In fact, as this condition reveals, there is considerable degeneration clearly manifest in the skull and jaws of these amphibians. The caudal vertebrae are of several types, some *acentrous,* some biconcave (*amphicoelous*) and some convex in front but concave behind (*opisthocoelous*). The trunk vertebrae bear ribs which may be well developed or reduced to mere vestiges. Both the pectoral and pelvic girdles are less completely ossified than in the stegocephalians. The limbs are attached to the girdles so that their proximal elements are usually at right

angles to the body, thus making for a slow, awkward, waddling gait. The pubis is never ossified; the bones of the limbs are less so than in their paleozoic relatives; the wrist (*carpus*) and ankle (*tarsus*) are rarely ossified. There are never more than *four* fingers on the hand although the foot generally has *five* toes. Claws are absent in all cases.

Fossil representatives of the *Caudata* are few and give little insight into their origin and the course of their development. Only one skeleton is known from the Mesozoic—*Hylaeobatrachus croyi* from the Lower Cretaceous of Belgium. This was a little fellow about four inches long, apparently with three pairs of gills. Its front legs were shorter than its hind pair, but the number of toes, four in front and five behind, is characteristic. It had extremely short ribs and its tail contained at least fifteen vertebrae. Its relationship to other caudates is uncertain but it seems to belong somewhere near the cryptobranchids (see below, p. 302).

Throughout the Cenozoic Era, the remains of *Caudata* are likewise very rare and mostly modern in structure and appearance. A newt has been recorded from the upper Eocene or lower Oligocene of France on the basis of a few detached vertebrae and limb-bones, under the generic name of *Megalotriton.* From the lower Miocene, near Bonn, have come fragmentary remains of *Molge* (=*Triton*). *Molge* is a member of the modern European fauna, but "*Tylotriton,* living today in southeastern Asia and on one of the Loo-Choo Islands (Iwo Jima), has recently been discovered in the Miocene of Switzerland" (Noble). From the upper Miocene of Oeningen, Switzerland, in 1726, came *Andrias,* a cryptobranchid genus about the size of the related giant salamander living today in China and Japan. *Triturus,* the common newt, is a well-known member of the living fauna in both Europe and North America, but it occurs also in the Miocene and more recent formations of Europe. Most finds of fossil caudates have consisted of fragments not sufficiently characteristic to determine with certainty their relationships to living genera. However, they suffice to make sure that salamanders lived in Europe at least as early as the Oligocene. This is the reason why Europe is and long has been the center of variation and dispersal of salamander species.

The *Subclass Caudata,* for our purpose, may be most conveniently divided into three orders:

1. The *Proteida;* 2. The *Mutabilia;* and 3. The *Meantes.*

Order 1. Proteida

The members of this order never lose their gills, hence are often referred as "perennibranchs". They include the well-known genus *Necturus,* with some seven named species, of which *Necturus maculosus,* the "mudpuppy" living in the streams throughout the eastern United States from the Great Lakes to the Gulf States and westward into eastern Kansas, is the largest and best known species. It is commonly used as an "example" of a *primitive* caudate in courses in comparative anatomy. The second genus is *Proteus,* the blind, usually rosy white newt, or "olm", of the caves of Austria and other nearby parts of Europe. It turns dark, almost black, when exposed to light for a considerable time and is famous among zoölogists because it has the largest red blood-corpuscles of any known vertebrate. It is somewhat less than a foot in length, whereas *Necturus* may reach a length of 18 inches.

It is generally agreed that these two genera are *permanent larvae* as indicated by the largely cartilaginous skull; the absence of maxillary bones; the mutual relations of the palatines and pterygoids; the absence of eyelids; and the retention of the plumose external gills. In fact the whole branchial apparatus is larval except the loss of the fourth arch. Another striking larval character is the lack of the *rectus abdominis* muscle. *Proteus* is even more larval than *Necturus,* since it has only three fingers and two toes on its appendages, whereas *Necturus* has four and four. Both genera habitually *walk on the bottom,* though capable of rapid swimming under the propelling power of the well-developed compressed tail which is provided with large dorsal and ventral median fins. No fossil representatives of this order are known.

Order 2. Mutabilia

This order may be divided into three natural suborders, termed respectively the *Cryptobranchoidea,* the *Ambystomoidea,* and the *Salamandroidea.* Though distinct enough now, they all appear to point back to a common ancestry.

The members of the *Cryptobranchoidea* are probably the most primitive of the *Mutabilia* as shown by the more generalized condition of the skull and skeleton, the persistent gill-slits, and the small eyes without obvious lids. They are permanently aquatic. To this suborder belongs *Crytobranchus alleganiensis,* the "hell-bender", found in the rivers and smaller streams from western New York state through Pennsylvania to the Ohio River and its tributaries, and

south to Georgia and Louisiana. It is particularly at home in the Alleghany Mountains of Virginia. It reaches a length of 18 to 20 inches, and is looked upon with superstitious fear by fishermen who may catch it on the hook when after catfish. It is really altogether harmless and probably as good to eat as catfish. Its gill-slits are normally reduced to one pair. Its color is brown or dark gray above, and lighter below. It feeds voraciously upon worms, crustaceans and small fish, and is said to destroy great quantities of the valuable whitefish. Its larva is unknown.

Our *Crytobranchus* is a smaller relative of the giant Japanese salamander, *Megalobatrachus,* living in China as well as in Japan, which sometimes reaches a length of five feet or more. It is used for food by the natives of those countries. It differs from our hellbender also in the total absence of gill-slits and in the associated modifications of the branchial apparatus. It occurs in small mountain streams at elevations varying between 600 and 4500 feet above sea-level. It feeds upon worms, insects, fishes and amphibians. It has been known to live for more than fifty years in captivity.

The *Hypnobiidae* of eastern Asia, the most primitive of all existing *Mutabilia,* also belong to the *Cryptobranchoidea.* Structurally they are very close to known extinct fossil forms. Certainly belonging in this suborder is the famous *Andrias scheuchzeri* from the upper Miocene of Oeningen, Switzerland, referred to above, discovered in 1726 and described by Scheuchzer himself as *"Homo diluvii testis", i.e.,* a man who was a witness of the Noachian deluge. If it has not been removed or destroyed in this war, it is in the Teyler Museum in Haarlem, Netherlands. It is about three feet long as preserved, but in life may have been as large as the living giant salamander of Japan. Another smaller species (*Andrias tschudii*) occurs in a lignite deposit near Bonn, and still another has been taken from the coal beds of Bohemia. Only one fossil cryptobranchid has thus far been found in North America, and this was described by Dr. Harold J. Cook from the lower Pliocene of Nebraska under the generic name of *Plicognathus.* It may well have lived in Kansas, though as yet not recognized here.

The *Suborder Ambystomoidea* includes only one family with but six recorded genera: *Ambystoma, Dicamptodon, Rhyacotriton, Plioambystoma, Lanebatrachus* and *Ogallalabatrachus,* comprising over a dozen species, living or extinct, and widely distributed from southern Alaska to Mexico, and from Long Island and the Atlantic Coastal Plain, as far south as Florida, westward to Texas and

Mexico; also across southern Canada from Ontario to British Columbia; and throughout all the continental United States, except New England and a few other localities of unfavorable habitat.

All the Ambystomids are very much alike in form but are extremely varied in color pattern. With the exception of *Ambystoma opacum* which lays its eggs on land in the fall, all the ambystomids deposit their eggs in the water, usually in small ponds among brush very early in the spring, often before the ice has melted. All their larvae are very similar, with external gills, laterally compressed head and tail. The most wide-spread species is the common and well-known Tiger Salamander (*Ambystoma tigrinum*), the "water dog" often found in Kansas around ponds and stock-tanks, in cellars or cisterns, and in other damp situations. Its larval form is called the "axolotl" and has a head that is higher than broad, while in the adult it becomes broader than high, and thus takes on the proportions usual to the group. This metamorphosis, which involves changes in color and in the form of other parts of the creature, is so great that the young was long supposed to belong to a different genus (*Siredon*) from that to which the adult is assigned (*Ambystoma*). This conclusion was supported by the fact that neoteny occurs in this salamander and the larva is often larger than the regular adult, and reproduces without undergoing metamorphosis.

Among the fossil ambystomids from Kansas, *Lanebatrachus martini* (type, KUMVP No. 1468) from the Middle Pliocene, Edson quarry, Sherman County, and *Ogallalabatrachus horarium* (type, KUMVP No. 1470), from the Middle Pliocene, Rhino Hill quarry, Wallace County, were both based on fragmentary material by Dr. E. H. Taylor. Very little can be said about these two salamanders except that they are undoubtedly ambystomids.

The sensational find of thousands (probably more than 30,000) of small fossil amphibian bones by the late H. T. Martin in the Edson quarry in Sherman County, Kansas, on a branch of the Smoky Hill River, representing at least 150 individuals, brought to light a new ambystomid genus, described by Dr. L. A. Adams of the University of Illinois and H. T. Martin under the name of *Plioambystoma kansense* (type, KUMVP No. 5250). The deposit is middle Pliocene and lies about twenty feet below the level of the surrounding prairie. The bones are mostly disarticulated, but the fossilization is complete, and the bones are in such excellent condition that they can be articulated and studied as though fresh. The new form agrees with the *Ambystomidae* in all determinable points that are

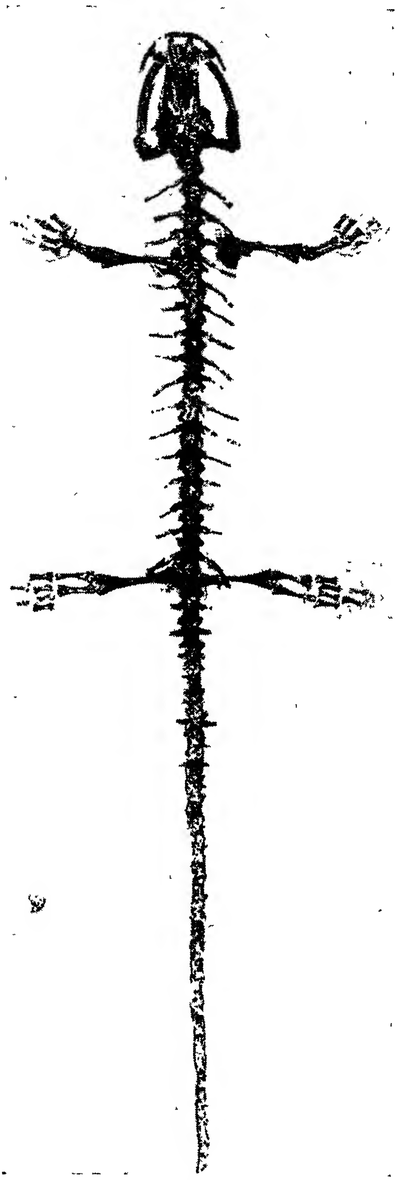

FIG. 6. Type of Plioambystoma kansense. From the Edson Quarry, Sherman County. From photograph. Natural size.

characteristic of the family, yet it differs in others so that it is generically distinct. Apparently, as reassembled by Adams, the animal had sixteen body vertebrae (an axis and fifteen vertebrae with ribs), the sacral being the seventeenth, and there were about thirty to thirty-five caudals. Adams was able to reassemble several practically complete skeletons — only a very few unimportant elements being lost. (Fig. 6.) He notes that *Plioambystoma* is the first member of its family recorded from the Pliocene. "It thus represents a group that was in all probability ancestral to some of the present day *Ambystomidae*" (Adams). The two genera mentioned above, *i.e., Lanebatrachus* and *Ogallalabatrachus,* especially the former, probably were closely related to *Plioambystoma.*

The Museum of Natural History of the University of Kansas has other, but unidentified, "salamander" material from both the upper Pliocene (Rexroad) and the Pleistocene (Borcher) of Meade County, Kansas. Also, over 1200 specimens of larval *Ambystoma tigrinum* were studied by J. A. Tihen (1942) from the late Pleistocene, Jones Fauna, Meade County. Hence this form, now common in Kansas must have been equally common in the Pleistocene here.

The upper Cretaceous Judith River Beds have yielded a few vertebrae of two genera described by Cope as *Scapherpeton* and *Hemitrypus,* which may have been ambystomids, but their remains are too fragmentary for definite assignment. Ambystomid remains from the Pleistocene are more numerous. Thus, Barnum Brown, of the American Museum, found in the Conard Fissure, in Arkansas, a number of vertebrae and other bones that may even belong to the genus *Ambystoma.*

The genera *Dicamptodon* and *Rhyacotriton* are western forms confined to the humid coastal region—the first ranging from southern British Columbia to Southern California; while the latter is confined to the Olympic Mountains. "*Dicamptodon* is the largest *land* salamander in the world, attaining a length of 271 mm." (Noble), *i.e.* almost a foot.

The *Suborder Salamandroidea* is an extremely heterogeneous group that includes all those forms that not only undergo a distinct metamorphosis, but have teeth on the roof of the mouth well back of the internal nares. This suborder includes such typically aquatic forms as the newts (*Triturus*) and *Amphiuma,* as well as such thoroughly terrestrial forms as the lungless plethodons. It is represented by a variety of species on every continent, except Australia, though most of them are found in Eurasia.

The family *Salamandridae* is confined to Europe and Asia, except for the American newts of the genus *Triturus,* a genus which is not, however, itself confined to this continent. No fossil newt from North America is known to me.

The family *Amphiumidae* has but the single genus, *Amphiuma,* comprising two species, both living in the southeastern part of the United States as far west as Louisiana and Missouri. In both, the limbs are very small and end in two or three very tiny fingers or toes. The body and tail are rounded. A single pair of small gill-slits are persistent. The general color is black above and lighter below. *Amphiuma means* reaches a length up to three feet; *A. tridactyla* is measured only in inches. They live in swamps and muddy waters, occasionally burrowing in the muck, feeding upon crayfish, mollusks, small fish, etc. The eggs are laid in August or September, and the female coils about them until they hatch in November or December. The newly hatched young have well developed external gills. The gills are lost before the following February when the young are about three inches long.

The amphiumids are semi-larval types, as indicated by their

lidless eyes, the parallel arrangement of the teeth on the maxillary and vomerine bones, the presence of four branchial arches, and the bi-concave vertebrae. Because of these larval features, *Amphiuma* has been mis-grouped with the cryptobranchids, with which in fact it has no near relationship. No fossil members of this family are known.

The family *Plethodontidae* includes the majority of the species of American salamandroids. They live in small streams or on land, and apparently they arose in North America from a salamandroid stem. Only a few are yet known outside this continent, one genus having spread to southern South America, and another has reached Europe, where it is represented by two species in the Mediterranian region. Undoubtedly this genus spread westward from America through Asia, though it is not yet recorded from the latter continent. The plethodontids are regarded as being more specialized than the salamandrids, since their vomerine teeth "are carried back by processes during ontogeny to lie over the parasphenoid as either one or two dentigerous patches. The pterygoid either fails to ossify, remaining entirely cartilagenous throughout life, or is represented by a small bony nodule" (Noble). The several genera recognized in this family form a very natural series. Despite the fact that so many of them are strictly terrestrial as adults, they are all *lungless*, and have only the thin moist skin of the general body surface to function as an organ of respiration. They all "possess a nasolabial groove to assist in freeing the nostril from the water" (Noble). This character alone serves to distinguish a plethodontid from any other salamander, "but without a hand-lens the fine groove from nostril to lip is sometimes difficult to see" (Noble). The body musculature of the plethodontids is also specialized, resembling that of *Salamandra*, which is also strictly terrestrial.

But the most curious of all the plethodontids is *Typhlomolge*—a veritable "walking skeleton", with its long slender legs too weak to support the weight of its body when out of the water, and wearing a "white shroud". *Typhlomolge* came to light from an artesian well, 188 feet deep, near San Marcos, Texas. It has four fingers and five toes which are slender and pointed but not webbed. "The legs are used for locomotion and the animals creep along the bottom of the aquarium with a peculiar movement, swinging the legs in irregular circles at each step. They climb easily over rocks piled in the aquarium, and hide in crevices between them. The head is large, the mouth square. All efforts to induce them to eat have been futile.

The eyes are completely hidden beneath the skin and the whole animal is colorless and white. The tail is furnished with a dorsal and a ventral fin. The three pairs of gills are remarkable for their blade-like stalks, while the gill-lamellae proper are short and restricted to the tapering ends. The total length is about 75 mm." (Gadow). No fossil plethodonts are known.

Subclass III. Salientia

This subclass is represented in Kansas at the present time by the toads, tree-toads and frogs. It is apparently a natural group of amphibians, all of which have short bodies and long legs, but no tails in the adults. Their hind limbs differ noticeably from those of the *Caudata* in having *four* segments instead of the *three* occurring in the latter, and they function as powerful levers in leaping. In the terrestrial toads the hind legs are relatively not so large as they are in the more aquatic frogs. When resting undistrubed at the top of the water, a frog assumes a very ungraceful pose, with his front legs outspread from the sides of the body and his hind legs hanging down limply in the water below. But this apparently careless sprawl is not without effectiveness, for if threatened from above a single movement of the hind-legs upward pulls the frog well below the surface of the water, and his outspread fore-limbs are in exactly the position to effect most expeditiously the down-turn of the head and body necessary to bring the frog as quickly as possible into a place of safety.

From the fossil record few facts have been recorded that give us light upon the evolutionary history of the *Salientia*. The oldest known genera are *Montsechobatrachus,* of uncertain relationship, from the Upper Jurassic of Spain, and *Eobatrachus* from the Upper Jurassic of Wyoming. From their fragmentary remains it can only be determined that they were either frogs or toads, but even this makes it certain that this subclass goes back at least beyond the middle of the Mesozoic Era.

Order 8. Anura

The *Order Anura* is the only one that we may recognize in this subclass. Its characteristics are the same as those of the *Salientia* in general. The American representatives of this order include the frogs, toads and tree-toads, all of which are familiar to every child. Five suborders are recognizable on the basis of the form of the vertebrae, as follows:

Suborder a. Amphicoela, as the name indicates, has *biconcave*

vertebrae. Its one family and two genera are of particular interest since they are the most primitive anurans living today. That this is a *remnant* group, probably long ago widely distributed over the earth, is indicated by the fact that the genus *Liopelma*, only 1½ inches long, is found only in New Zealand where it is the sole amphibian native to these islands, while the other genus, *Asaphus*, occurs in North America. Both genera are primitive in that they possess *two muscles for wagging the tail, an organ which neither of them possess*. Moreover, *Asaphus* is the only frog in the United States that has a cloacal extension that serves as a copulatory organ when mating. No fossils of this suborder are known.

Suborder b. Opisthocoela includes two families of toad-like forms which have their vertebrae *concave behind* but *not in front*. The tongue in one is not protrusible and has the form of a circular disk attached to the floor of the mouth by nearly its whole base; the other is tongueless. They are both primitive in having short, free ribs borne on the lateral processes of the second to fourth vertebrae. No opisthocoelan is known from Kansas, either living or fossil.

Suborder c. Anomocoela includes forms that are intermediate in structure between amphicoelids and opisthocoelids, on the one hand, and the bufonids (true toads), on the other hand, without apparently having any close relationship to either side. At no time do they have free ossified ribs; the sacral vertebra is concave in front, and immovably fused behind with the urostyle, or if not so fused, then with only a single condyle for articulation with the urostyle. There are eight vertebrae anterior to the sacrum, all of which are *concave in front*. The one family, called the *Pelobatidae*, is widely distributed throughout the northern hemisphere. They are usually so toad-like in appearance that no one except a student of the group probably would distinguish the two forms. In Kansas, the living *Pelobatidae* comprise only the genus *Scaphiopus*, or "spade-foot toads", so-called because on the inner side of the foot they have a large, broad and sharp-edged tubercle, borne on a *prehallux—i.e.*, an additional toe preceding the "big toe" in position—which serves as a spade in digging. The most easily noted distinguishing feature is the *vertical* pupil of the eye. The skin is only slightly tubercular ("warty"). The true toads have a "warty" skin and a *horizontal* pupil in the eye. The living species in Kansas is *Scaphiopus bombifrons* Cope, which has its *toes* distinctly webbed, *fingers* only partly so. It has been recorded from Barton, Finney, Ford, Greeley, Morton, Reno, Rice and Sherman Counties in this state.

The known fossil spade-foot toads include *Macropelobates* from the Oligocene of Montana; *Pelobates* itself from the lower Miocene of Europe; *Scaphiopus* from the middle and upper Pliocene of Kansas; and *Neoscaphiopus* from the upper Pliocene of Meade County. The genus *Scaphiopus* includes three fossil species, all described by Dr. E. H. Taylor. One of these, *Scaphiopus studeri,* is a medium sized spade-foot more nearly like *S. bombifrons* Cope than any other living form, but is also related to *S. pliobatrachus,* mentioned below. It has a total length from snout to vent of about 58 mm., and the type specimen lies on a split slab of marl, each

FIG. 7. Type of Scaphiopus studeri, from E. H. Taylor, in K. U. Science Bulletin, Vol. XXV, June 1, 1938, plate XLIII. About natural size.

portion of which comprises both imprints and bones of a single animal. (Fig. 7). This is noteworthy as being probably the most perfect specimen of a fossil anuran yet found anywhere in the world. It was presented in 1936 to Dr. Claude W. Hibbard for the University of Kansas Museum of Vertebrate Paleontology, in which col-

lection it is catalogued as No. 1478. Its finder was Mr. Frank Studer, of Wallace, Kansas, for whom the species was named by Taylor. It came from a bed of diatomaceous marl in Logan County. This bed of marl lies in contact with the "Rhino Hill Quarry" beds, which are of middle Pliocene age.

From the Edson Beds, Ogallala formation, middle Pliocene of Sherman County, came the second species of fossil spade-foot, *Scaphiopus antiquus* (type, KUMVP, No. 1469), and the third species, *S. pliobatrachus* (type, KUMVP, No. 1430), both described by Taylor. A fourth species, *S. diversus* (type, KUMVP, No. 6368) is from the Rexroad formation, Blancan Age, Meade County, Kansas, and likewise was named and described by Taylor. It is about two inches long from tip of snout to vent, and is therefore smaller than *Scaphiopus bombifrons* Cope, living in western Kansas at the present time. From the same spot came a new genus of spadefoot, described by Taylor under the name of *Neoscaphiopus noblei* (type, KUMVP, No. 6367).

Suborder d. Procoela, including the "true toads", tree-toads and a few others less commonly recognized, forms a very natural group all of which have the vertebrae uniformly *concave in front* and the sacral vertebrae with a double condyle for articulation with the *urostyle*—a long slender bone formed by the fusion of the caudal vertebrae into one element. The ribless presacral vertebrae are five to eight in number. One family, the *Palaeobatrachidae,* is extinct and includes two genera, *Palaeobatrachus* and *Protopelobates.* They occur from the Jurassic to the Miocene in Europe only. *Palaeobatrachus* seemingly was aquatic since it had very long metacarpals, which equal the radius in length and are only slightly shorter than the humerus.

The second family, the *Bufonidae,* includes the "true toads", which are familiar to every child because of their "warty" skin and their terrestrial habit. They lack an ossified *sternum* ("breast bone") such as is present in the frogs, and the two sides of the *pectoral* ("shoulder") girdle slide across each other in the mid-ventral line, constituting what is called an *"arciferal girdle".* The transverse processes of the sacral vertebra are cylindrical or dilated at the distal end. All the members of this family—and they are many—except the common genus *Bufo,* are confined to Africa and southern Asia. *Bufo,* however, is almost worldwide in its distribution, occurring everywhere on land except in Madagascar, Australia, New Guinea and neighboring regions of the south-west Pacific.

Fossil bufonids come from the Miocene or later deposits of Europe and North America. From Kansas two species have been described by Taylor: *Bufo arenarius* (type, KUMVP, No. 1452) and *Bufo hibbardi* (type, KUMVP, No. 1437), both from the Edson Beds, Ogallala formation, middle Pliocene, Sherman County. Besides the types, much additional material representing each of these species is also in the University of Kansas Museum of Natural History.

The tree-toads (*Hylidae*) usually have their toes provided with claws and in many cases with adhesive pads; they are mostly tree-dwelling. Exceptions are the almost minute aquatic *Acris*, or "cricket frog", and the terrestrial or fossorial *Pternohyla* (not recorded from Kansas). *Hyla* is the most widespread genus, being absent only from Ethiopia, Madagascar, India, Malaya and the islands of the sea. All the other genera occur only in America. *Hyla* in particular is noted for its chameleon-like ability to change the color of its skin surface to blend with its immediate environment. As the moisture in the air approaches the saturation point just preceding a rain, *Hyla* becomes more and more pleasurably affected and finally breaks into a "song" that is popularly regarded as a prognostication of rain.

Suborder e. Diplasiocoela comprises the "true" frogs and their closest allies, including the Old World "tree-frogs" (*Polypedatidae* —not to be confused with the American *Hylidae*), and the narrow-mouthed "toads", or *Brevicipitidae*. In the members of this suborder the first seven trunk vertebrae are *concave in front;* the eighth is *biconcave.* The sacral vertebra has its centrum *convex* anteriorly, while posteriorly it carries *two condyles* for articulation with the *urostyle.* There are no ribs, and the shoulder girdle articulates with a *sternum* ("breast bone"), the right and left halves of which do *not* slide the one over the other, as in the toads. Instead of having an "arciferal girdle", therefore, the frogs are said to be *"firmisternal"*.

The members of this suborder, culminating in the family *Ranidae,* are the most highly specialized of all the anurans. Some are primarily aquatic, some terrestrial, and some are even fossorial. They occur over most of the land surface of the world, except Australia, New Zealand, and the southern end of South America. Africa seems to have been their original home. Of the many living genera, only two, *Rana* and *Gastrophryne,* now occur in North America.

While the *Ranidae*—true frogs—are the most highly specialized of the *Salientia,* they are nevertheless characterized by a high

degree of structural uniformity. The shoulder girdle displays scarcely any variation in form among the various genera and species and the same is true also of the skull.

The genus *Rana* occurs in the fossil condition from the Miocene and later formations of both Europe and North America. While there are five living species of *Rana* recorded from Kansas and one of the related *Gastrophryne,* it is interesting to note that two genera, *Rana* and *Anchylorana,* the first with seven and the second with three species, have been described by Taylor from the upper Pliocene of Meade County. These are:

Rana valida (type, KUMVP, No. 5133) from the Rexroad formation, Blancan Age; *R. rexroadensis* (type, KUMVP, No. 6369); *R. ephippium* (type, KUMVP, No. 6370), a small frog; *R.meadensis* (type, KUMVP, No. 6376), a medium-sized frog; *R. fayae* (type, KUMVP, No. 6378); *R. parvissima* (*sic*) (type, KUMVP, No. 6451), a very diminutive frog the relationship of which, according to Taylor, is very probably with the "woodfrogs" represented in the eastern United States today by *Rana sylvatica* and *Rana catabrigensis.* Kansas now has no living representative of this group the habitat of which is the heavily wooded regions where deciduous trees abound. The seventh fossil species (KUMVP, No. 6379) has not been named, but is listed by Taylor from the Rexroad fauna.

The second fossil genus, *Anchylorana,* has three species so far recognized, all by Taylor, and all from the same locality as the seven species of *Rana* just referred to. *Anchylorana moorei* (type, KUMVP, No. 6375), a small frog only about 2½ inches long from snout to vent, is known only from Meade County, Kansas. *Anchylorana dubita* (type, KUMVP, No. 6377) is a much smaller species than *A. moorei,* being scarcely more than 2 inches from snout to vent. *Anchylorana robustocondyla* (type, KUMVP, No. 5106) is "a rather large frog" (Taylor).

Taylor has presented in tabular form a comparison of the recent *Salientia* in Kansas with the fossil species in the Rexroad fauna, and this shows:

	Recent Fauna		Rexroad Fauna	
Family	Genus	Species	Genus	Species
Pelobatidae	1	1	2	2
Bufonidae	1	4	1	2
Ranidae	1	2	2	10
Hylidae	2	3	0	0
Microhylidae	1	1	0	0

Totals:
Recent ......5 families, 6 genera, 11 species
Rexroad ......3 families, 5 genera, 14 species

The following comments by Taylor are of sufficient interest to be quoted here. He says:

It seems safe to postulate that a very much larger amphibian fauna was present in the Rexroad than is represented by the finds to date. So large a number of ranid frogs warrants the postulation that the climate was such as to supply a much heavier rainfall, in order to provide sufficient moisture for these water-loving frogs. It seems strongly probable that with forests, which would be concomitant of the heavier rainfall, numerous species of the *Hylidae,* small *Leptodactylidae* and *Microhylidae* would be present. It is likewise probable that there was also a population of small salamanders, although not a single species has been so far recovered [from the Rexroad]. . . . The present climate of North Carolina supports an anuran population of 26 species and subspecies, representing 5 families and 8 genera. The *Caudata* are even richer with 40 species and subspecies, representing 6 families and 16 genera. In the case of the caudate fauna the mountainous character of the country is a factor contributing to its diversity. While the two areas are not entirely comparable, the presence in the Rexroad of so large a number of *Rana* in the fauna suggests the possibility that the climates were similar in character, and at least the anuran fauna may eventually prove even richer than the present day fauna of North Carolina.

Of the ranid species in the Rexroad fauna, in comparison with those living in Kansas today, *none is identical.* . . . The present day *R. brachycephala* apparently approaches closely to *Raña valida.* They are, however, not identical.

In regard to the Edson Quarry, middle Pliocene, Ogallala formation, of Sherman County, Kansas, Taylor remarks:

One of the surprising facts concerning this fauna is the abundance of *toads* and the seeming absence of ordinary frogs of the genus *Rana,* which today are usually the most conspicuous members of any amphibian fauna in the United States. . . . This is not true of the amphibian fauna of the upper Pliocene deposits of Meade County, Kansas, or the Broadwater beds of Nebraska, because in both places frogs of the genus *Rana* predominate, and toads are rare or absent.

Previous to the publication of the papers by Taylor, referred to above, the fossil remains of frogs and toads of the Western Hemisphere had been little studied, and only 7 species of extinct anurans had been described from this enormous area. The salamanders were scarcely better known. Now, at least 16 species of frogs and toads, and 4 of salamanders are known from western Kansas alone.

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Charles Darwin's Last Letter?

EDITOR'S NOTE—In April, 1882, James E. Todd, professor of natural science in Tabor College, Iowa, published in the *American Naturalist* (volume 16, pages 281-287) a paper, "On the Flowers of Solanum Rostratum* and Cassia Chamaecrista". The paper soon came to the attention of Charles Darwin, then in his seventy-fourth year. Almost immediately Darwin wrote the letter to Professor Todd which we publish below, for the letter does not appear in the two-volume *Life and Letters of Charles Darwin* prepared by Francis Darwin, son of the famed scientist. Professor Todd, from 1907 until his death in 1922, was a member of the geology staff of the University of Kansas and the existence of the Darwin letter was then known to members of the University of Kansas staff. Recently, however, Professor R. Q. Brewster, of the University department of chemistry, wrote to Mr. E. A. Todd of El Dorado, Kansas, a son of Professor Todd, concerning the letter and Mr. Todd generously replied by giving the letter to the University. The manuscript letter is now in the University of Kansas Library.

The most extraordinary feature of the letter is its date, written nine days before Darwin's death on April 19, 1882. Darwin had been in poor health for some time and beginning in December, 1881, underwent a series of heart attacks. He rallied from these attacks and, as the letter indicates, by April was still mentally active and planning work for the future. Five days after writing the letter his final illness began. Possibly this letter was his last scientific one; the last letter published in *Life and Letters* is dated March 27, 1882. My colleague, Dr. H. H. Lane, calls my attention to the fact that the letter below does not appear in *More Letters of Charles Darwin* (also compiled by Francis Darwin, published in two volumes and containing 782 Darwin letters) published, of course, after Francis Darwin's original work. Professor Todd is mentioned in this second compilation (volume 2, p. 292) but there is no mention of the letter Darwin wrote Todd. The date of the last Darwin letter in this second work is March 23, 1882. Darwin had a note in *Nature* for the issue of April 6, 1882 (p. 529) and this note appears to be his last communication to the scientific world before the Todd letter.

Dr. Fritz Müller, referred to by Darwin in the letter below, carried on an extensive correspondence with Darwin for many years although the two naturalists never met; in one letter Darwin wrote Müller with apparent envy of living "as retired a life as you in Brazil." Darwin's memory was still good, despite the doubt expressed below, for Müller had published "on the subject" in *Kosmos* (volume 4, p. 481, 1879). The book to which Darwin refers in his postscript is *The Various Contrivances by Which Orchids are Fertilized by Insects,* first published in 1862 with a second edition in 1877.

The original four-page letter is all in Darwin's hand except the printed address in the upper right-hand corner of the first page. The letter reads as follows:

Transactions Kansas Academy of Science, Vol. 48, No. 3, 1945.

*Professor Todd also identified this species by its common name, the Texas nettle, and stated that it had been introduced "within a few years" in southwest Iowa. My colleague, Professor W. C. Stevens, tells me that the plant is now commonly called the Texas thistle.

Down,
Beckennam, Kent
Railway Station
Orpington. S.E.R.

April 10 1882

Dear Sir

I hope that you will excuse the liberty which as a stranger I take in begging a favor of you. I have read with unusual interest your very interesting paper in the American Naturalist on the structure of the flowers of Solanum rostratum, and I shd. be grateful if you would send me some seed in a small box (telling me whether to plant in as annual, so that I may know when to sow the seeds), in order that I may have the pleasure of seeing the flowers and experimenting on them. But if you intend to experiment on them, of course you will not send me the seeds, as I shd. be very unwilling to interfere in any way with your work. I shd. also rather like to look at flowers of Cassia chamaecrista.

Many years ago I tried some experiments in a remotely analagous case and this year am trying others. I described what I was doing to Dr. Fritz Müller (Blumenau, St. Catharina, Brazil) and he has told me that he believes that in certain plants producing 2 sets of anthers of a different colour, the bees collect the pollen from one of the sets alone. He wd. therefore be much interested in your paper, if you have a spare copy that you could send him. I think, but my memory now often fails me, that he has published on the subject in Kosmos.

Hoping that you will excuse me, I remain, Dear Sir

Yours faithfully

Ch. Darwin

P.S. In my little book on the Fertilization of Orchids, you will find under Mormodes ignea, an account of a flower laterally asymmetrical and what I think that I called right-handed or left-handed flowers.

The Photochemical Gaseous Phase Chlorination of Isobutane

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The study of aliphatic chlorination being carried out by the authors has several objectives: first, to determine the relative rates of substitution of hydrogen atoms on primary, secondary, tertiary, and once- and twice-substituted carbon atoms, particularly in the trichlorides, tetrachlorides, and more highly substituted alkyl chlorides, and upon which there has been no previously published work; second, to determine the effects of various catalysts on the production of structural isomers; third, to identify and determine the physical properties of the isomeric chlorides not previously reported in the literature; and fourth, to study the heretofore neglected chemical properties of the highly substituted alkyl chlorides (these properties include hydrolytic reactions, reactions with potassium permanganate, reactions with anhydrous aluminum chloride, and dehalogenation reactions); fifth, to produce olefinic chlorides, and to study the effect on polymerizability of chlorine atoms in the olefin molecule. These problems are being limited to the two butanes, n-butane and iso-butane, and their chlorides. The first part of this work on iso-butane is nearing completion and some of the methods and results obtained so far are here discussed.

When chlorine reacts with a paraffin hydrocarbon, chlorine atoms are substituted for hydrogen atoms in the alkane and a molecule of hydrogen chloride is evolved for every chlorine atom substituted. This reaction is complicated, not only by the fact that substitution does not stop after the addition of one chlorine atom to the molecule, but continues until two, three, four, and more chlorine atoms have been substituted; but also because there are produced a number of the different structural isomers which are theoretically possible for the monochloride, dichloride, trichloride, etc.

For example, in the case of isobutane, there are theoretically possible two monochlorides, three dichlorides, four trichlorides, and six tetrachlorides—a total of 15 different compounds possible if the reaction proceeds only to the tetrachloride stage. The number of structural isomers of isobutane, however, is small compared to that of n-butane because there are 31 different compounds theoretically possible by the reaction of chlorine with n-butane, providing the reaction stops at the tetrachloride stage.

Fortunately, however, the task of separating the various compounds from the mixture of chlorinated products obtained by chlorinating isobutane was simplified by two factors: first, only 10 different compounds of all those theoretically possible were actually isolated and two of these in such small amounts that a determination of their physical properties was impossible; and, second, the separation of the mixture of chlorinated products into its components was achieved after two or three fractionations by a very efficient fractionating column which will be described shortly.

On the subject of gaseous phase chlorination of hydrocarbons, most textbooks of organic chemistry make statements to the effect that the reaction is very vigorous, even explosive, and must be modified by use of excess hydrocarbon, diluent gases, or co-solvents. However, the chlorinator developed for this study so harnesses the reaction that no modification of the conditions under which the reaction takes place is necessary, and the reaction proceeds without requiring any especial attention. In fact, this type of chlorinator affords an excellent, but simple, means for preparing alkyl chlorides in any laboratory. (See Fig. 1.)

The reactor used for the chlorination of isobutane is somewhat similar to that shown in the diagram, although several important

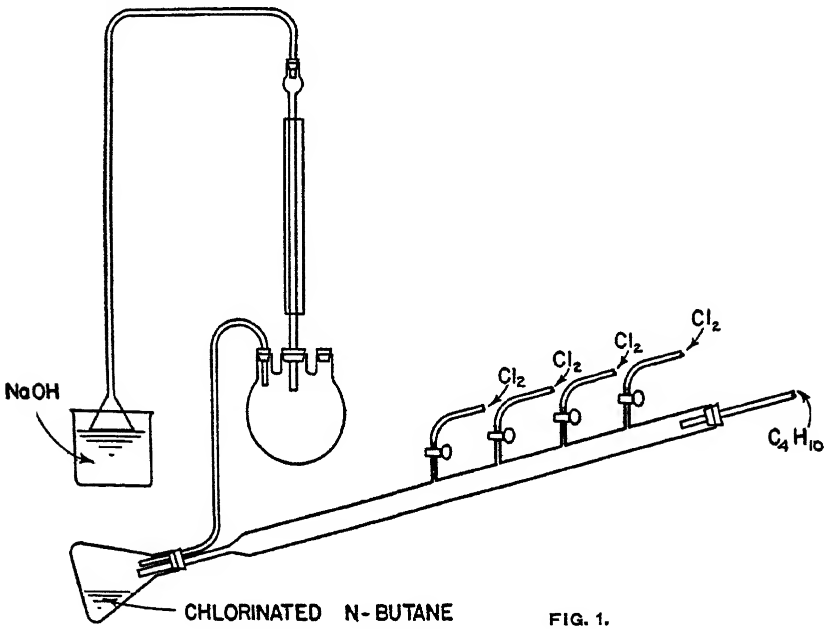


FIG. 1.

details have since been added. The reaction is carried out at room temperatures and pressures, and the reactor is surrounded by four 25-watt lamps. The reaction is shown to be definitely photo-chemical since the chlorination of isobutane under similar conditions in the absence of light, decreases the yield about 86%.

The effect of the ratio of hydrocarbon to chlorine on the amounts of the various chlorides produced, and the amount of chlorinc and hydrocarbon which react is shown in Tables 1 and 2.

TABLE 1.

Results of a chlorination run in which the ratio of mols of isobutane to mols of chlorine was approximately 1:1.

Time of run=5.00 hours.

Temperature=26°C. Pressure=734 mm. Hg.

Inlet	Rate of flow	Total mols passed
Isobutane	835cc/min.	9.89
Chlorine, 1	270cc/min.	3.19
Chlorine, 2	302cc/min.	3.57
Chlorine, 3	315cc/min.	3.72

Total Cl_2=10.5 mols; total C_4H_{10}=9.89 mols.
Ratio mols C_4H_{10}/mols Cl_2=0.94
Total yield of chlorinated product=621 g.

Frationation Results

Compound	Yield	Weight %	Mols	Mol %
2 chloroisobutane	178 g.	28.7%	1.92	33.3%
1 chloroisobutane	217 g.	34.9%	2.35	40.7%
1, 1 dichloroisobutane	—	—	—	—
1, 2 dichloroisobutane	46 g.	7.41%	0.36	6.24%
1, 3 dichloroisobutane	40 g.	6.44%	0.31	5.37%
1, 1, 2 trichloroisobutane	47 g.	7.57%	0.29	5.03%
1, 2, 3 trichloroisobutane	61 g.	9.82%	0.38	6.59%
(1, 1, 2, 3) tetrachloroisobutane	31 g.	4.99%	0.16	2.77%
X, X, X, X, X pentachloroisobutane	1 g.	0.16%	0.004	0.07%
Total	621 g.	100%	5.77	100%

$$\% \text{ Isobutane reacted} = \frac{5.77}{9.89} \times 100 = 58.3\%$$

$$\% \text{ Chlorine reacted} = \frac{8.28}{10.5} \times 100 = 78.9\%$$

These tables represent two typical chlorination runs, one in which the ratio of hydrocarbon to chlorine is approximately 1:1 (Table 1) and in the other 1:2 (Table 2). Several interesting conclusions can be drawn. When the ratio of hydrocarbon to chlorine is 1:2, a situation which ideally should produce a 100% yield of dichlorides, only 24% of all the chlorides obtained are dichlorides; but when the ratio of hydrocarbon to chlorine is raised to 1:1, a situation which if ideal would yield all monochlorides, 74% of the chlorides obtained are monochlorides, that is, the reaction becomes more ideal, in this respect, as the ratio is raised.

When the ratio of hydrocarbon to chlorine is 1:3, 28% of the theoretical yield is 1, 2, 3 trichloroisobutane; thus, this represents a means of preparing this trichloride.

In 1935-1936, H. B. Hass and E. T. McBee* made an extensive study of the chlorination reactions of a large number of different

*See *Ind. Eng. Chem.* 29, 1335 (1937) and prior references.

TABLE 2.

Results of a chlorination run in which the ratio of mols of isobutane to mols of chlorine was approximately 1:2.

Time of run=6.25 hours.

Temperature=26°C. Pressure=734 mm. Hg.

Inlet	Rate of flow	Total mols passed
Isobutane	840cc/min.	12.4
Chlorine, 1	495cc/min.	7.33
Chlorine, 2	560cc/min.	8.27
Chlorine, 3	700cc/min.	10.4

Total Cl_2=26.0 mols; total C_4H_{10}=12.4 mols.

Ratio mols C_4H_{10}/mols Cl_2=0.48

Total yield of chlorinated product=1393 g.

Frationation Results

Compound	Yield	Weight %	Mols	Mol %
2 chloroisobutane	175 g.	12.6%	1.89	17.2%
1 chloroisobutane	273 g.	19.6%	2.95	26.8%
1, 1 dichloroisobutane	—	—	—	—
1, 2 dichloroisobutane	186 g.	13.4%	1.46	13.3%
1, 3 dichloroisobutane	150 g.	10.8%	1.18	10.7%
1, 1, 2 trichloroisobutane	190 g.	13.7%	1.17	10.6%
1, 2, 3 trichloroisobutane	260 g.	18.7%	1.60	14.5%
(1, 1, 2, 3) tetrachloroisobutane	128 g.	9.2%	0.65	5.9%
pentachloroisobutane	28 g.	2.0%	0.12	1.1%
Others	2 g.	0.1%	0.01	0.1%
Total	1393 g.	100%	11.0	100%

$$\% \text{ Isobutane reacted} = \frac{11.0}{12.4} \times 100 = 88.7\%$$

$$\% \text{ Chlorine reacted} = \frac{21.7}{26.0} \times 100 = 83.5\%$$

aliphatic hydrocarbons, but their work was confined almost entirely to monochloride and dichloride formation. At the conclusion of their work, they formulated eleven rules of chlorination. In general, these rules are in agreement with the results obtained by the authors. For example, (1) no isomerization to produce chlorides of n-butane was found to take place in the chlorination of isobutane at room temperatures and pressures; (2) hydrogen atoms are always substituted at rates which are in the order tertiary > primary, as indicated, for example, by the predominance of 1, 2 dichloroisobutane over 1, 3 dichloroisobutane and by the fact that no trichloroisobutanes were isolated in which the hydrogen on the tertiary carbon atom had not been substituted; and (3) the fact that no 1,1 dichloroisobutane was obtained from the chlorinated products of isobutane indicates that in gaseous phase chlorination the presence of a chlorine atom on a carbon tends to hinder further reaction upon that carbon during the second substitution.

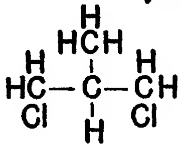
This latter conclusion, however, appears to apply only to the second substitution, since there is formed an appreciable amount of 1,1,2 trichloroisobutane by the third substitution. In fact, in the present stage of identification of structure of the two unidentified polychlorides there is a strong indication that, in tetra and penta substitution, chlorine atoms add almost exclusively to carbon atoms on which there is already a chlorine atom present. Verification of this

type of behavior and the publication of numerical ratios of rates of substitution must await more positive proof of the structure of these polychlorides, a project which is now being carried on.

TABLE 3.

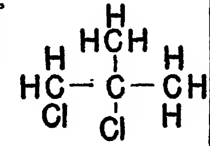
Some of the physical properties of the isobutyl chlorides obtained by the direct chlorination of isobutane

1,3 dichloroisobutane



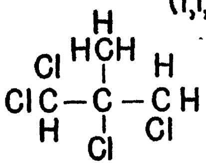
$BP_{49mm} = 60.0° - 60.8°$
$BP_{727mm} = 135.0°$
$N_D^{30°} = 1.4477$
$D_4^{30°} = 1.1375$

1,2 dichloroisobutane



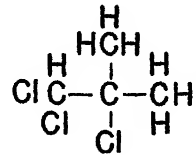
$BP_{49mm} = 33.4° - 33.6°$
$BP_{140mm} = 56.8° - 57.0°$
$BP_{727mm} = 105.5°$
$N_D^{30°} = 1.4327$

(1,1,2,3) tetrachloroisobutane



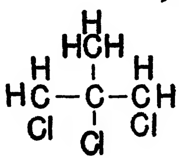
$BP_{49mm} = 103.9° - 104.9°$
$BP_{727mm} = 187.°$
$N_D^{30°} = 1.4905$
$D_4^{30°} = 1.4072$

1,1,2 trichloroisobutane



$BP_{49mm} = 66.7° - 67.1°$
$BP_{727mm} = 143.5°$
$N_D^{30°} = 1.4621$
$D_4^{30°} = 1.2612$

1,2,3 trichloroisobutane



$BP_{49mm} = 81.2° - 81.8°$
$BP_{727mm} = 161.0°$
MP = (sets to glass at -82°)
$N_D^{30°} = 1.4716$
$D_4^{30°} = 1.2934$

X,X,X,X,X pentachloroisobutane

$BP_{20mm} = 100.8 - 102.0°$
$BP_{727mm} = 207.0°$

Table 3 shows some of the physical properties determined for the chlorides of isobutane obtained by chlorination.

The fractionating column used for the separation of the mixed chlorination products into pure components is shown in Figure 2. This column was constructed with the help of Dr. Calvin Vander Werf and Messrs. Robert Russell and Frank Jirik.

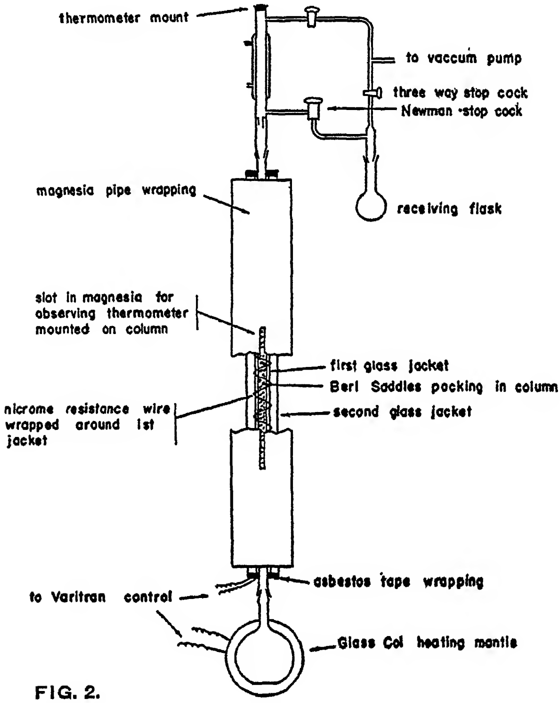


FIG. 2.

The chemical properties of the chlorides which have been tested thus far and the methods by which the structures of the chlorides have been determined will appear in a future publication. In regard to this latter point it may suffice to say that the structures have been based on physical constants reported in the literature, hydrolysis products, olefinic products produced by removal of HCl from the alkyl chloride molecule, combustion analysis, and molecular weight determinations.

The authors wish to express their appreciation to Dr. Vander Werf for the use of his fractionating column and for his helpful suggestions; to Mr. Frank Jirik, who did most of the glass work required, and to other members of the chemistry department of the University of Kansas who have aided this research project.

Mexican Amphibians and Reptiles in the Texas Cooperative Wildlife Collections

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Through the courtesy of Dr. William B. Davis of Texas Agricultural and Mechanical College, we have been permitted to examine and report upon the entire series of Mexican amphibians and reptiles in the Texas Cooperative Wildlife Collections. The specimens were accumulated on summer trips over a period of two years, 1941 and 1942, by Dr. Davis and his students. Collecting of herpetological material was incidental to mammalogical work, yet a surprisingly valuable lot was secured. A summary of the mammals has been published by Davis (1944), who likewise included a map, a list and brief characterization of all the localities visited by his parties.

The herpetological collection consists of 332 specimens representing 70 species. Among these are paratypes of two new races (one, *Ameiva undulata amphigramma,* described herein, the other, *Crotalus gloydi lautus,* described by Smith, 1945). There are in addition specimens of four very rare species (*Ambystoma subsalsum, Syrrhophus pipilans, Laemanctus serratus,* and *Tantilla bocourti deviatrix*); eight new state records (seven from Tlaxcala, one from Hidalgo); and a variety of other data of special interest.

Taxonomic changes proposed in this paper are as follows:

Sceloporus grammicus=*Sceloporus grammicus grammicus*

Sceloporus microlepidotus microlepidotus=*Sceloporus grammicus microlepidotus*

Sceloporus microlepidotus disparilis=*Sceloporus grammicus disparilis*

Ameiva undulata amphigramma subsp. nov.

Tantilla bocourti=*Tantilla bocourti bocourti*

Tantilla deviatrix=*Tantilla bocourti deviatrix*

In addition we have included a key to the mainland Mexican forms of *Phrynosoma.*

We are indebted to Dr. W. B. Davis for his generous cooperation throughout the course of the study; to Dr. A. B. Leonard for his kindness in forwarding comparative material of the genus *Ameiva;* and to Dr. E. H. Taylor for his assistance in identification of certain specimens.

Ambystoma subsalsum Taylor

A single adult, transformed specimen (No. 1021) from Alchichica, Puebla, 8300 feet, was collected by J. M. Vajdos on August 8, 1942.

This is the second adult known of the species; the first is the type (Taylor, 1943: 151-156, Figs. 1-3). It is larger than the type, measuring 94 mm. from snout to posterior end of vent; the tail measures 67 mm., and is about 71% of the body length (61% in type). The tail is more elongate than in the type, and its greatest depth is 10.5 mm.; it maintains this depth (approximate) from a point near the base distally to the middle of the tail, where the latter begins to taper posteriorly. The costal grooves number 13 on either side. The tongue lamellae are longitudinal, as described by Taylor. The maxillary-premaxillary teeth number 57-51, the vomeropalatine series 33-33. The arm measures 32 mm., the leg 35 mm., head length from gular fold, 20 mm.; head width 18.5 mm. The pattern of the type is almost exactly duplicated; the occipital, postorbital and paired dorsal spots are present as described; the belly is clouded. Many of the digits have been amputated.

Pseudoeurycea leprosa (Cope)

The collection contains 11 specimens. Nine are from Monte Río Frío, 45 kilometers southeast of Mexico City, México, 10,500 feet; of these, three (Nos. 704-706) were collected June 30, 1941, by R. L. Peterson, one (No. 703) June 29, 1941, by W. H. Bunger, one (No. 702) June 25, 1941, by W. B. Davis, and four (Nos. 903-906) on June 30, 1941 by J. L. Robertson and E. L. Rawlins. The two other specimens (Nos. 907, 908) were collected 55 kilometers southeast of Mexico City, México, 10,500 feet, on July 12, 1942 by M. H. Whisenhunt.

The specimens appear to be typical and have the dark body color and light chin characteristic of the species.

Chiropterotriton chiroptera (Cope)

A single adult specimen (No. 701) was taken 45 kilometers east southeast of Mexico City, México, collected by R. L. Peterson on June 30, 1941.

Scaphiopus hammondii multiplicatus Cope

Three specimens (Nos. 659-661) are in the collection, all from 17 kilometers east southeast of Mexico City, México, June 24, 1941, collected by R. L. Peterson.

Bufo compactilis Wiegmann

The collection contains eight specimens, all from the state of México. Three (Nos. 656-658) are from 17 kilometers east southeast of Mexico City, collected by R. L. Peterson on June 24, 1940. The remaining five are from 23 kilometers east of Mexico City, 7,500 feet: No. 979, collected by S. Stegall on August 8, 1942; Nos. 975-978 collected by E. M. Talk on July 30 and August 4, 1942.

The series is very uniform in structure and coloration. In all the parotoid gland is in contact with the postorbital crest. The dorsal mottling is very obscure; the belly varies somewhat in amount and intensity of pigmentation, one specimen being very dimly marked, another with few small spots, and still others with large, well-defined, irregular, dark markings. Only two of the series are males.

Bufo horribilis Wiegmann

The collection contains six specimens collected by W. B. Davis, M. H. Whisenhunt, H. L. Gilbert, R. R. Rusche, and D. H. Buck. Four of these (Nos. 962-965) are from Río Ramos, 20 kilometers northwest of Montemorelos, 1,000 feet, Nuevo León, June 8, 13, 18, and August 4, 1942. The other specimens (Nos. 966, 967) are from Río Aguacatillo, 30 kilometers north of Acapulco, 1,000 feet, Guerrero, August 4, 1942.

The name here used was resurrected by Taylor and Smith (1945:551-552).

Bufo punctatus Baird and Girard

Two specimens were collected by W. B. Davis in the state of Nuevo León in 1941: one (No. 793) at a locality 13 miles southwest of Sabinas Hidalgo, June 17; the other (No. 974) at Río Ramos, 20 kilometers northwest of Montemorelos, 1,000 feet, June 19.

One of either sex is represented. The female is very large, measuring 66 mm. from snout to vent.

Bufo simus Schmidt

Two adult specimens (Nos. 984, 985), both from 13 kilometers northeast of Tlaxcala, 7,800 feet, were collected by H. L. Gilbert on July 17, 1942. These are the first specimens reported from the state.

Bufo valliceps Wiegmann

The collection contains nine specimens as follows. *Tamaulipas*: 3 kilometers south of Antiguo Morelos, July 13, 1941, T. H. Shary (No. 696). *Nuevo León*: Río Ramos, 20 kilometers northwest of Montemorelos, 1,000 feet, M. H. Whisenhunt, June 4 and 13, 1942 (Nos. 980-983), W. B. Davis, June 19, 1941 (Nos. 971-973), R. L. Peterson, June 20, 1941 (No. 655).

The two young specimens (Nos. 655, 696) show the differences from the adults that seem to occur characteristically in this species (see Taylor and Smith, 1945:560); in the younger (No. 655) measuring 23 mm. snout to vent, the belly is very heavily mottled, and in the larger specimen (No. 696) measuring 30 mm. snout to vent, the chest is rather heavily mottled. In none of the adults are the ventral surfaces marked.

Eleutherodactylus natator Taylor

A single juvenile specimen (No. 1010) taken 5 kilometers north of Jalapa, Veracruz, 4,500 feet, collected by B. Leftwich on August 3, 1942.

The heel reaches distinctly beyond the tip of the snout.

Syrrhophus pipilans Taylor

A single adult specimen (No. 833) from Río Aguacatillo, 30 kilometers north of Acapulco, Guerrero, 1,000 feet, collected by W. B. Davis on August 3, 1942.

This specimen provides a second known locality for this species in Guerrero; elsewhere it is known from only one locality, near Tehuantepec, Oaxaca. This specimen has been compared with Taylor's description and figures (1940:95-98, pl. 1) with which it agrees in detail. The areolar character of the sides and the general character of the skin on the other portions of the body have been distorted somewhat by the distention of the skin, in turn probably due to manner of preservation. The pattern is well defined.

Agalychnis dacnicolor (Cope)

A single specimen (No. 1005) from Río Aguacatillo, 30 kilometers north of Acapulco, Guerrero, 1,000 feet, August 4, 1942, collected by D. H. Buck.

Kellogg (1932:142) records the maximum head and body length of this species as 83 mm.; the present specimen is an enormous female measuring 107 mm., snout to vent. Otherwise it appears typical.

Hyla baudinii baudinii Duméril and Bibron

Three specimens are present, two of which (Nos. 1003, 1004) are from Río Aguacatillo, 30 kilometers north of Acapulco, Guerrero, 1,000 feet, August 4, 1942, collected by D. H. Buck and H. L. Gilbert respectively. The third (No. 694) is from 19 kilometers north of Tamazunchale, San Luis Potosí, July 12, 1941, collected by J. H. Shary.

The specimens are typical adults, two males and one female.

Hyla eximia Baird

Two specimens (Nos. 1006, 1007) both from 45 kilometers southwest of Mexico City, México, 9,400 feet, August 16, 1942, collected by E. M. Talk.

This species is distinctly different from *lafrentzi* as indicated by the smaller adult size, the small tympanum, and the larger digital pads.

Hyla lafrentzi Mertens and Wolterstorff

The collection contains 32 specimens as follows. *Tlaxcala*: 13 kilometers northeast of Tlaxcala, 7,800 feet, July 15, 1942, R. R. Rusche (No. 1001). *Puebla*: Río Otlati, 15 kilometers northwest of San Martín, 8,700 feet, August 7, 1942, R. R. Rusche (No. 1002). *México*: 55 kilometers southeast of Mexico City, 10,500 feet, July 2, 9, 1942, M. H. Whisenhunt (Nos. 1012-1020); 45 kilometers east southeast of Mexico City, June 29, 1941, R. L. Peterson (Nos. 662-682).

The specimen from Tlaxcala constitutes a new record for that state.

There are only three females in the entire series; two of them are larger than any of the males.

Hyla miotympanum Cope

A single juvenile specimen (No. 1008) taken 5 kilometers north of Jalapa, Veracruz, 4,500 feet, was collected by T. Johnson on August 4, 1942.

Rana pipiens Schreber

The collection contains 17 specimens as follows. *Nuevo León*: Río Ramos, 20 kilometers northwest of Montemorelos, 1,000 feet, June 2, 1942, M. H. Whisenhunt (Nos. 986, 987); same, June 8, 1942, W. B. Davis (No 993). *Tlaxcala*: 13 kilometers northeast of Tlaxcala, 7,800 feet, June 15, 1942, R. R. Rusche (No. 992); 8 kilometers southwest of Tlaxcala, 7,500 feet, July 25, 1942, H. D. Turner (Nos. 989, 990); same, H. L. Gilbert (No. 991). *Puebla*: Río Otlati, 15 kilometers northwest of San Martín, 8,700 feet, August 9, 1942, B. Leftwich (No. 988). *Veracruz*: 5 kilometers north of Jalapa, 5,400 feet, August 4, 6, 1942, B. Leftwich (Nos. 994, 1011); same, August 5, 1942, T. Johnson (Nos. 995, 996, 1009). *México*: 45 kilometers southwest of México, 9,400 feet, August 16-18, 1942, E. Powell and S. Stegall (Nos. 997-1000).

Apparently this species has not been recorded previously from the state of Tlaxcala.

The specimens from Jalapa differ rather consistently from all the others in a number of characteristics. The dorsal spots are relatively few, the general dorsal tone is very dark, and the concealed surfaces of the thighs are extremely heavily mottled. The two juveniles from this locality are like the three adults in these characters. There seem to be no peculiarities in the Jalapa specimens as opposed to the others in limb, head, or body proportions.

Phyllodactylus lanei Smith

A single specimen (No. 970) from Río Aguacatillo, 30 kilometers north of Acapulco, Guerrero, is listed in Taylor's notes on the collection; we have not seen it.

Anolis nebuloides Bocourt

A single, typical adult male (No. 968) was collected at Río Aguacatillo, 30 kilometers north of Acapulco, 1,000 feet, August, 1942, by M. H. Whisenhunt.

Laemanctus serratus Cope

A single specimen of this rare species (No. 969), from Boca del Río, Veracruz, was collected by M. H. Whisenhunt on July 21, 1942.

The specimen is a fine adult male. The snout-vent length is 96 mm., tail 345 mm., snout-occiput length (measured along the flat dorsal surface of the head) 32 mm., head width 17 mm., hind leg 104 mm., fourth toe (measured from base of fifth) 40 mm., and foreleg 59 mm.

The dorsal head scales are finely rugose, and those on the snout are four to five times as large as those on the occiput. The scales on the snout are somewhat abnormal; the typical large pair follows the rostral, but behind it, instead of the typical second pair of scales, there is one large azygous scale, larger than any other on the snout; to one side of it is a small scale which might represent the right member of the pair of normally equal scales occupying this area; to either side of this second pair of scales are two scales, one following the other; the posterior pair of medial scales is present and normal. Remaining dorsal head scales subequal, small; a small frontal evident; parietal eye dimly evident in a small scale; supraorbital semicircles poorly defined, composed of slightly enlarged scales; supraoculars small, irregular, numbering five across the broadest area between the supraorbital semicircles and the superciliaries. Latter 8-9, small, subequal, not or feebly imbricate. Posterior margin of head with 12 projecting scales forming a serrated border.

Nasal single, nostril pierced in its center, in contact above with the canthal scales and below with the second and third supralabials. Four canthals, the anterior two in front of the nasal and in contact with the supralabials and rostral. Preoculars small, elongate, scarcely entering orbit, in contact with nasal on one side and separated on the other. Two rows of loreals, upper with 1-2 scales, lower with 3-4 scales. A row of circumorbitals extending around the anterior, ventral, and part of the posterior border of the orbit; 4-5 subocular scales in this series in contact with labials. Temporals uniform, about the size of the smallest occipital scales. Tympanum very large, vertically oval, about the size of the eye opening. Scales on neck below head

extremely small, grading into the somewhat larger scales on the underside of the crest. Supralabials 14-15, seven to below middle of orbit, the posterior ones merging into the lower temporals. Twelve infralabials, bordered medially by several series of sublabials somewhat larger than the median gular scales. Two chin shields in contact medially behind mental. Gular scales elongate, unicarinate, the keels converging toward the posterior central portion of the throat. Mesoptychials with single longitudinal keels, typical in form. Gular fold shallow. A middorsal series of elevated, enlarged, strongly keeled scales; the anterior scales in this series are more strongly serrate and elevated than those which follow, the extreme posterior scales being but little different from the adjacent dorsals.

Other dorsal scales gradually decreasing in size toward the sides, unicarinate, the keels converging medially. Lateral scales small, their keels extending longitudinally or ventrally. Ventral scales as large as dorsals, with single longitudinal keels. Scale rows around the middle of the body 53. Tail scales similar to body scales, uniform above and below. No middorsal series of scales on distal half of tail, but instead two rows of scales; six rows of scales around this portion of tail except at extreme tip where the number drops to four by loss of the lateral series. Scales on dorsal surface of foreleg about the size of largest dorsal body scales, uniform, keeled; ventral scales similar, somewhat smaller on upper foreleg. Subdigital lamellae with tubercle-like keels, one on each lamella, except those at the end of each phalanx, which generally are provided with two keels. Lamellar formula for fingers 9-16-22-23-13, 9-16-21-21-13.

Scales on thigh nearly uniform on all sides, about as dorsal body scales. Scales on shank similar, but larger and more heavily keeled. Lamellar formula for toes 9-16-24-32-18, 9-17-25-32-19.

Dorsal surface dark chocolate brown, somewhat lighter on head. Dim dark crossbands on body, most clearly evident on vertebral line, separated from each other by spaces equally as long as the bands. No markings evident on limbs or top of head. A dark streak extending from below the eye to the lower edge of the tympanum, bordered below by a light streak which passes beyond the tympanum to the base of the foreleg. Above the posterior part of this light streak is a fairly distinct dark mark, continuous with the first crossband. One or two dim light marks above axilla. A conspicuous light streak along the sides of the body from axilla to groin. Ventral surfaces light reddish purple, darker toward the posterior portion of the belly and on tail.*

This species has a rather wide range, extending from extreme northeastern Guanajuato along the lowlands toward the south, around the Gulf of México as far as the Yucatán Peninsula. Records are available in México from the following states: *Guanajuato*: Huasteca Potosina. *Hidalgo*: Zacualtipán. *Veracruz*: Boca del Río; Jicaltepec; Misantla; Orizaba. *Oaxaca*: Tlacolula. *Campeche*: Champotón, Oxpemul. *Yucatán*: Chichén Itzá. There is some possibility that the species may consist of several races; a number of

*It should be noted that the color of this species, like that of *Laemanctus deborrii*, may well be green in life. A color plate and brief comment on the color in life of the latter species (a preserved specimen of which is purplish) is given by Weber (1945:209, 210, pl. 14).

differences are apparent in the descriptions of specimens from Veracruz and Yucatán (Gaige, 1936:296).

Basiliscus vittatus Wiegmann

Three specimens from Veracruz are in the collection, two (Nos. 834, 836) from Boca del Río, July 20 and 21, 1942, collected by W. B. Davis and M. H. Whisenhunt, and one (No. 697) from Puente Nacional, July 7, 1941, R. L. Peterson. No. 836 is a female which had seven eggs in the oviducts, each about 29x14 mm. in size.

Iguana iguana rhinolopha Wiegmann

Four specimens (Nos. 699, 693, 755, 775) are from Puente Nacional, Veracruz, collected July 7, 1941, by R. L. Haines and R. L. Peterson. Two are half-grown, with two well defined and one ill-defined median tubercles on the snout. In the two juveniles (75-76 mm. snout to vent) the tubercles are not evident.

Holbrookia texana (Troschel)

The collection contains five specimens, all from Nuevo León; three (Nos. 783-785) are from 13 miles southwest of Sabinas Hidalgo, collected by W. B. Davis, June 17, 1942; two (Nos. 899, 948) from Río Ramos, 20 kilometers northwest of Montemorelos, 1,000 feet, collected by W. B. Davis, M. H. Whisenhunt, *et al.*, June 13, 19, 1942.

The series consists of one adult male, two adult females, and two very immature females measuring 25 mm. snout to vent.

Sceloporus formosus scitulus Smith

A single adult male (No. 1021C) from 15 kilometers southwest of Chilpancingo, Guerrero, 9,000 feet, was collected by H. D. Turner on August 18, 1942.

Dorsal scales 30; femoral pores 14-14; coloration apparently typical, although the body is discolored; the large light spots on the head, typical of this race, are discernible.

Sceloporus spinosus spinosus Wiegmann

Four specimens are in the collection. One (No. 923) is from a locality 23 kilometers east of Mexico City, México, 7,500 feet, collected by E. Powell, August 4, 1942. Three others (Nos. 698, 753, 754) are from 26 kilometers east of Zimapán, Hidalgo, 5,500 feet, collected by W. H. Bunger and W. B. Davis, July 11, 12, 1941.

There are four supraoculars on one side of each of three specimens, otherwise there are five. Respectively the femoral pores number 7-7, 10-9, 9-9, and 8-8.

Sceloporus olivaceus Smith

A single specimen (No. 909) is from Río Ramos, 1,000 feet, 20 kilometers northwest of Montemorelos, Nuevo León, collected June 8, 1942, by W. B. Davis.

This is a typical female with eight crossbars on the body between the dorsolateral light stripes. The supraoculars are large, five on each side, and are separated from the superciliaries by one row of small scales posteriorly,

and from the median head scales by one complete row of scales. The femoral pores number 12-13, the dorsal scales 31. No markings are visible ventrally. Snout to vent, 92 mm. There is no tendency whatever toward the characters of *spinosus*.

Sceloporus horridus horridus Wiegmann

Two specimens (Nos. 922, 937) are from Guerrero. The former is from El Naranjo, 30 kilometers south of Taxco, 3,250 feet, collected by D. H. Buck, August 3, 1942; and the latter is from 15 kilometers south of Chilpancingo, 4,300 feet, collected by H. D. Turner, August 18, 1942.

Each specimen has 4-4 supraoculars and 4-4 femoral pores.

Sceloporus grammicus microlepidotus Wiegmann

Thirty-five specimens are from the following localities. *México*: 55 kilometers southeast of Mexico City, 10,500 feet, June 30-July 9, 1942, M. H. Whisenhunt and S. H. Wheeler (Nos. 838-840, 928); Monte Río Frío, 45 kilometers east southeast of Mexico City, June 25-30, 1941, W. B. Davis, J. H. Shary, W. H. Bunger, R. L. Peterson (Nos. 714-719, 725-733, 736-737, 925-927, 955, 961); North slope of Mt. Popocatepetl, 13,500 feet, July 30, 1942, W. Delaney (Nos. 841-842). *Puebla*: 12 kilometers north northeast of San Andrés, west slope of Mt. Orizaba, 10,000 feet, August 11, 1942, W. Delaney (No. 843); Río Otlati, 15 kilometers northwest of San Martín, 8,700 feet, August 1, 1942, W. B. Davis (No. 902). *Tlaxcala*: eight kilometers southwest of Tlaxcala, 7,500 feet, July 24, 1942, H. L. Gilbert (Nos. 959-960). *Veracruz*: northwest slope of Cofre de Perote, 10,500 feet, July 29, 1942, L. A. Follansbee (Nos. 957, 958).

The Tlaxcala specimens constitute the first record for that state.

The dorsal counts range from 68 to 88 (68, one; 70, two; 72, four; 73, two; 74, one; 75, three; 76, two; 77, one; 78, two; 79, three; 80, two; 81, three; 82, one; 83, one; 85, two; 87, one; 88, one). It is noteworthy that the two highest counts were obtained on the specimens from the highest elevation (Nos. 841, 842); this suggests that in *g. microlepidotus,* as in *malachiticus smaragdinus,* the dorsals increase in number as the elevation increases.

Previously *grammicus* has been considered a full species, while *microlepidotus* and *disparilis* were regarded as subspecies (Smith, 1939:179-197). Material collected by the senior author in 1939 and 1940, however, during tenure of the Walter Rathbone Bacon Traveling Scholarship, proves rather conclusively that all three forms are races of a single species and that complete intergradation occurs between *grammicus* and *microlepidotus* as well as between the latter and *disparilis.* Eighty-six specimens (now in the U. S. National Museum) were collected of *g. grammicus* at San Pedro Quiechapa, Oaxaca, and two at Omilteme, Guerrero. The dorsal scales vary from 53 to 66 in 59 of the Oaxaca specimens, and average 59.5. The two Guerrero specimens have 60 and 64 dorsals. Two others from Chilpancingo, Guerrero (U.S.N.M. Nos. 47601-2) have 58 to 63 dorsals; one from Ozolotepec, Oaxaca (U.S.N.M. No. 47846) has 64; one from Tamazulapan, Guerrero (U.S.N.M. No. 46400) has 64. Accordingly a wide distribution for this large-scaled subspecies is indicated in the elevated areas south of the central Mexican plateau. Five specimens from Cerros San Felipe and San Juan, north of Oaxaca City, indicate that in that area intergradation between *g. grammicus*

and *g. microlepidotus* may occur, for the dorsal counts in these specimens are 61, 63, 68, 69, 70. A specimen from farther north in Oaxaca (Reyes, No. 47369) has 72 dorsals, and represents the southernmost known locality for typical *g. microlepidotus.*

The scale counts of *g. grammicus* are almost identical with those of *g. disparilis,* both of which have larger, less numerous dorsals than *g. microlepidotus,* which widely separates the former two. In fact, these two are so remarkably similar in all features of scutellation that no character has been found, in this respect, which may serve to distinguish them, aside from the greater degree of mucronation on the dorsal and lateral scales of *g. grammicus.* In the latter, the dorsal and lateral scales have strong, long terminal mucrones, and are heavily keeled; in *g. disparilis* usually the dorsal scales are feebly keeled, and not or weakly mucronate, while the lateral scales are but little more strongly keeled and mucronate. There is some variation in this character, as southern *g. disparilis* tend to have the keels and mucrones more strongly developed (an influence of *g. microlepidotus,* in which the individual scales, while smaller than in either of the other two subspecies, are similar in character to those of *g. grammicus*). Variation in pattern is so great that the only reliable divergence from each other of *g. grammicus* and *g. disparilis* is in the anterior extent of the blue areas on the sides of the abdomen in the male. In the former these areas do not quite reach the axilla, while in *g. disparilis* they reach a little anterior to the axilla. In general *g. disparilis* is a little lighter in color than *g. grammicus.*

These differences between the extreme southern and northern subspecies are admittedly small. If the populations compared were adjacent, the differences possibly would not be considered sufficiently recognizable. However, since the two large-scaled populations are so widely separated from each other by the small-scaled subspecies, it seems best to recognize the differences, however small, and to retain as distinct subspecies *Sceloporus grammicus grammicus* and *Sceloporus grammicus disparilis.*

Sceloporus serrifer plioporus Smith

A single adult male (No. 837) is from Boca del Río, 10 feet, Veracruz, collected July 21, 1942, by W. B. Davis.

As is typical of the race, most of the dorsal head scales have light central spots, and the keels on the dorsal body scales are streaked with dark gray or black. Dorsal scales 30; femoral pores 11-12; supraoculars large, 4-4, undivided; snout to vent length 87 mm.

Sceloporus torquatus torquatus Wiegmann

Four specimens (Nos. 858, 934-936), all from Lago Zempoala, 45 kilometers southwest of Mexico City, México, 9,400 feet, were collected by E. Powell, August 15-17, 1942.

Supraoculars large, in a single row. Frontal contacting interparietal in three, separated by frontoparietals in one. Prefrontals in contact in two, separated by an azygous scale in two. Femoral pores 17-18, 20-16 (the series is doubled on one side), 18-19, and 20-18 respectively.

Wiegmann's name *torquatus* has been reinstated since it has been determined by the International Commission on Zoological Nomenclature that secondary homonymity does not suppress a name.

Sceloporus mucronatus mucronatus Cope

The collection contains a fine series of 21 specimens. Eight (Nos. 850-857) are from a locality 55 kilometers southeast of Mexico City, México, 10,500 feet, collected by M. H. Whisenhunt and S. H. Wheeler, on July 2-12, 1942. The other 13 (Nos. 654, 713, 720, 721, 744-752) are from Monte Río Frío, 45 kilometers east southeast of Mexico City, México, collected by W. B. Davis, W. H. Bunger, R. L. Haines, and R. L. Peterson, on June 25-30, 1941.

Frontal in contact with interparietal in eight specimens, separated by frontoparietals in five, and by an azygous scale in eight. Prefrontals contact each other in all specimens but one, in which an azygous scale occurs. Femoral pores 10-14 (10, three; 11, three; 12, twenty-one; 13, seven; 14, one). The specimens are very typical of the species and are amply differentiated from the remarkably similar species *torquatus*. Females and young specimens possess paired longitudinal gular lines. All have a mid-dorsal series of large dark spots.

Sceloporus cyanogenys Cope

Two adult specimens (Nos. 781, 782) are from 13 miles southwest of Sabinas Hidalgo, Nuevo León, collected June 17, 1941, by W. B. Davis.

Both are typical adult females measuring 104 mm. and 81 mm. respectively, snout to vent. The tail bands are very obscure. Dorsal scales 35, ?; femoral pores 13-14, 13-13; supraoculars 5-5, 5-?, of which two to four are split; median head scales normal, regular. No tendency toward the characters of *poinsettii* are evident in these specimens.

Sceloporus variabilis variabilis Wiegmann

In a series of nine specimens, one (No. 867) is from a locality five kilometers east of Las Vigas, Veracruz, 8,000 feet, collected August 3, 1942, by W. B. Davis. This elevation is unusually high for the race, although Blatchley (probably in error) records it on Mt. Orizaba at elevations as great as 14,000 feet. This specimen is a juvenile male with 56 dorsal scales.

The other eight (Nos. 757-764) are from Puente Nacional, Veracruz, collected by R. L. Peterson on July 6, 7, 1941. The dorsal scales of these specimens respectively are 56 (♂); 60 (♂); 60 (♀); 58 (♂); 53 (♀); (56 (♂); 57 (♀); 58 (♂); 54 (♀).

Sceloporus variabilis marmoratus Hallowell

Two specimens are from Río Ramos, 20 kilometers northwest of Montemorelos, 1,000 feet, Nuevo León; No. 932 was collected June 5, 1942, by Max Whisenhunt, and No. 933 on September 1, 1942, by H. L. Gilbert.

Both are immature; the female (No. 932) has 69 dorsal scales, the male 60.

Sceloporus scalaris scalaris Wiegmann

Twelve specimens, all adults, are from the state of México: three (Nos. 929-931) 23 kilometers east of Mexico City, 7,500 feet, E. Powell and E. M. Talk, August 6-9, 1942; and nine (Nos. 844-846, 949-954) 17 kilometers east-southeast of Mexico City, R. L. Peterson, June 24, 1941.

Two typical males are in the series; all the others are females. Only one

of the females does not contain well-developed eggs. One female contained large numbers of the exoskeletons of curculionid beetles in the rectum, and another contained a large winged ant in addition to the beetles.

In two specimens the anterior canthal is fused with the subnasal, and in two other specimens it is considerably reduced in size; however in only one specimen is the anterior canthal completely lacking or its fusion not clearly evident. In that single specimen it appears on one side that it may have been fused with the posterior canthal.

The extent of parallelism between *aeneus* and *scalaris* is extraordinary. *S. scalaris* can usually be distinguished by the presence of two canthals, for within its range only *a. aeneus,* with one canthal, occurs; most useful, however, as a distinguishing characteristic is the ashy ventral color of *aeneus,* creamy white of *scalaris.* Males of the two species are, of course, widely different in ventral pattern; likewise the tibia is noticeably longer in *scalaris,* and the maximum size considerably greater.

Sceloporus aeneus aeneus Wiegmann

Seven specimens, all adults, are available: one (No. 849) from Lago Zempoala, 45 kilometers southwest of Mexico City, México, collected August 13, 1942, by E. Powell; and six (Nos. 722-724, 734, 735, 924) from Monte Río Frío, 45 kilometers east-southeast of Mexico City, México, June 25-29, 1941, W. B. Davis and R. L. Peterson.

Typical and from well within the known range of this race is the specimen from Lago Zempoala, with canthals 1-1, dorsals 44, femoral pores 14-16 (♀).

The series from Monte Río Frío is of very great interest, however, since it represents populations of an area intermediate geographically between the known ranges of the races of *aeneus, viz. a. aeneus* and *a. bicanthalis.* The latter occurs in the eastern Sierras of Veracruz and Hidalgo, and in Oaxaca; *a. aeneus* is the typical dark form occurring in the state of México and westward. From the intermediate zone in Puebla the only recorded specimens are from Puebla (locality questionable) and Mt. Popocatépetl. All these, save one from the latter locality (secured by a different collector and on a different date from the others and therefore probably from a different portion of the volcano) were referred by Smith (1939: 356, 361) to *a. aeneus.* However, none of these localities is very precise, and the specimens do not appear to represent intergrading populations. The Monte Río Frío specimens are, however, intergrades, and thus afford the first real evidence that the forms actually blend in the geographic zone intermediate between the ranges of typical specimens.

Only one male is present in the Río Frío series; it is dark below as is typical of *a. aeneus;* however three of the females have streaked chins, as in *a. bicanthalis.* Two of the streaked females have 2-2 canthals; all other specimens have 1-1 as is typical of *a. aeneus.* These are the two most important characters differing between the two races; and on the basis of the variation in them in these specimens one can conclude that the individuals represent an intergrading population probably approaching *a. aeneus* more closely than *a. bicanthalis.*

Monte Río Frío is on the divide between the eastern (Gulf drainage)

and western (Pacific drainage) slopes of the ridge from which Mts. Ixtaccíhuatl and Popocatépetl have been thrust. Ten kilometers farther east Whisenhunt collected apparently typical *a. bicanthalis;* thus it may be inferred that typically *a. bicanthalis* occurs on the eastern slopes of this ridge, *a. aeneus* on the western. Such an interpretation lends credence to the supposition that both forms can and do occur on Mt. Popocatépetl, as previously indicated by specimens in the Museum of Comparative Zoology and in the U. S. National Museum (Smith, 1939: 356, 361).

Dorsals 41, 42, 43, 40, 40, 41; femoral pores 18-18 (♂), 16-18, 18-?, 15-?, 16-16, 14-16, respectively.

Sceloporus aeneus bicanthalis Smith

The collection contains six specimens referred to this race. Four typical specimens (Nos. 938-941) are from a locality five kilometers east of Las Vigas, Veracruz, 8,000 feet, collected August 1, 1942, by W. B. Davis. The largest of these, not full-grown, measures 38 mm. snout to vent and is sufficiently immature that the belly is still mostly light-colored; there is a dusky suffusion, however, and there are a number of dark streaks on the chin. Dorsal scales, respectively, 39, 40, 40, 38; femoral pores 14-15, 17-17, 16-17, 15-15; sex, ♀, ♂, ♀, ♂; canthals 2-2 in all.

Two other specimens (Nos. 847, 848) are, apparently, typical enough, but were collected so near the range of *a. aeneus* (55 kilometers southeast of Mexico City, México, 10,500 feet, M. H. Whisenhunt, July 2 and 12, 1942) and the area of intergradation between the two forms that it is questionable whether they accurately represent the population of their locality. The locality is, it may be noted, only 10 kilometers east of Monte Río Frío, a site where Dr. Davis and his party collected a series of six *aeneus,* which, although of intergradient character, are here referred to the typical subspecies, *a. aeneus* (see discussion of latter). The two available, however, so clearly exhibit the characters of *a. bicanthalis* that they must be allocated with that form for the present, with the reservation that further specimens from the same locality may necessitate consideration of that population as an intergrading one perhaps more closely allied to *a. aeneus* than to *a. bicanthalis.* Both specimens are adult females, and show the relatively light belly and distinctly striped chin and gular region typical of *a. bicanthalis;* the canthals are 2-2 in each, although forced above the canthal ridge in each by contact of the second canthal and subnasal; dorsal scales 41, 41, femoral pores 14-14, 15-16, respectively.

Phrynosoma orbiculare (Linnaeus)

Six specimens represent this species in the collection. *Guerrero*: Tierra Colorada, 600 feet, M. H. Whisenhunt, August 4, 1942 (No. 947). *México*: 23 kilometers southeast of Mexico City, 7,500 feet, E. W. Bonn, August 2, 1942 (No. 946); 17 kilometers east southeast of Mexico City, R. L. Peterson, June 24, 1941 (No. 651). *Tlaxcala*: 13 kilometers northeast of Tlaxcala, 7,800 feet, R. R. Rusche, July 21, 1942 (No. 945). *Puebla*: Río Otlati, 15 kilometers northwest of San Martín, 7,800 feet, H. D. Turner, August 9, 1942 (No. 944). *Veracruz*: five kilometers east of Las Vigas, 8,000 feet, W. B. Davis, August 1, 1942 (No. 942). We believe that the specimen which purports to be from the state of Guerrero bears incorrect data, for the species

is not known otherwise from localities off the main plateau of México; the specimen may well have arrived at this locality by artificial means. The specimen from Tlaxcala apparently provides a new record for that state.

There is a great deal of variation in the specimens, which do not segregate clearly into two forms on the basis of characters used in the past (Boulenger, 1935:241-242; Smith, 1935:290-292, Figs. 1, 2, 5, 6). In some the occipital spines extend beyond the temporals, and in others they are on a par with them or a little shorter. In no specimen are the occipital spines directed mesad. In all the specimens head width is greater than head length. The ventral pigmentation also varies considerably, the Tlaxcala specimen with the fewest and lightest markings; the supposed Guerrero specimen and the two from southeast of Mexico City have the darkest markings.

The variation in these six specimens thus agrees with that observed by the senior author several years ago in 61 other specimens in the U. S. National Museum from various Mexican localities. It was impossible on the basis of those specimens to segregate recognizable populations. The extent of variation from one locality to another is surprisingly great; specimens from practically every locality differ from others in some minor respect, and correlation with biotic areas is not evident.

The species and subspecies of *Phrynosoma* we now recognize in mainland México may be distinguished by the accompanying key.

KEY TO MAINLAND MEXICAN *Phrynosoma*

1. Series of enlarged scales below infralabials very widely separated from latter by a maximum of six or seven scale rows; no horns.................*ditmarsi*
   Series of enlarged scales below infralabials narrowly separated from latter by a maximum of three or four scale rows; horns present, although reduced in some species 2
2. Gulars very unequal, with several rows of enlarged, pointed scales separated from each other by small scales ....*asio*
   No more than two series of enlarged scales in gular region 3
3. No differentiated lateral fringe of spines.................*modestum*
   One or two lateral fringes of spines................. 4
4. Four occipital spines, two on each side; no conspicuous break between temporal and occipital spines................. *solare*
   Two occipital spines, one on each side; conspicuous break between temporal and occipital spines.................5
5. Tail shorter than head.................6
   Tail longer than head 7
6. Temporal region produced posteriorly, terminating in a spine much larger than occipital spines.................*taurus*

Temporal region not produced posteriorly; occipital spines a little larger than temporals .... *braconnieri*

7. A conspicuous group of enlarged, keeled, pointed scales in middle of posterior surface of thigh; tympanum hidden; two lateral fringes of spines at least anteriorly .... *m'callii*

   No enlarged, keeled scales on posterior face of thigh; tympanum hidden or not; one or two lateral fringes 8

8. Two lateral fringes of spines .... *cornutum*

   One lateral fringe 9

9. Tympanum hidden .... *platyrhinos goodei*

   Tympanum exposed 10

10. Occipital spines larger than postorbitals 11

    Occipital spines more or less subequal to postorbitals 12

11. Occipital spines nearly erect, while temporal spines approach the horizontal, all relatively long; top of head conspicuously concave, superciliary region elevated .... *boucardi*

    Occipital spines on same plane as temporals, approaching the horizontal, all shorter; top of head flat .... *orbiculare*

12. Tail shorter than head is broad, or very slightly longer in adults .... *douglassii brachycercum*

    Tail longer than head is broad, much more so in adults .... *douglassii hernandesii*

Eumeces copei Taylor

Two specimens are in the collection. One (No. 712) is from Monte Río Frío, 45 kilometers east southeast of Mexico City, México, collected by R. L. Haines on June 29, 1941. The other (No. 910) is from a locality 55 kilometers southeast of Mexico City, México, 10,500 feet elevation, collected by M. H. Whisenhunt on July 3, 1942.

The first specimen is an adult measuring 60 mm. from snout to vent; the other is a juvenile measuring 32 mm. The scale rows around the middle of the body are 23 and 24 respectively. They appear to be typical in scutellation and pattern.

Ameiva undulata amphigramma subsp. nov.

Holotype. An adult male, E. H. Taylor-H. M. Smith Coll. No. 11983, collected at San Andrés Tuxtla, Veracruz, by H. M. Smith, 1935.

Paratypes. Thirty-three including two topotypes, E.H.T.-H.M.S. Nos. 11982, 11984; E.H.T.-H.M.S. No. 11684, Jalapa, Veracruz; E.H.T.-H.M.S. Nos. 11968-11976, 11978-11981, Tierra Colorada, Veracruz, E. H. Taylor and H. M. Smith, 1932; Texas Cooperative Wildlife Coll. No. 767, Puente Nacional, Veracruz, R. L. Peterson, July 6, 1941, and No. 825, Boca del Río,

Veracruz, M. H. Whisenhunt, July 21, 1942; Walter Rathbone Bacon Coll.* Nos. 1779, 2119, 7203-7209, vicinity of Potrero Viejo, Veracruz, Dyfrig McH. Forbes, 1938; W. R. B. C. No. 1777, near Orizaba, Veracruz, Dyfrig McH. Forbes, 1938; W. R. B. C. No. 3964, Cosolapa, Oaxaca, H. M. Smith, January 11, 1939; W. R. B. C. Nos. 2045, 2046, Atoyac, Veracruz, H. M. Smith, December 17, 1938; W. R. B. C. Nos. 12784, 12785, Matías Romero, Oaxaca, H. M. Smith, January 25, 1940.

Diagnosis. A member of the *undulata* group of *Ameiva,* closely related to *u. stuarti,* but differing from that in three prominent features of the color pattern: adult males possess a broad, longitudinal, light, upper lateral stripe, situated just below the median border of the lateral dark zone of the body; there is a complete absence in specimens of all sizes of a narrow dark stripe bordering the dorsolateral light lines medially; and the dorsolateral light stripes nearly completely disappear in adult males. Preanals in two rows, median gulars in a single row.

Description of holotype. Rostral about as high as wide in straight line measurements; preseminasals in contact medially behind rostral, their median suture nearly as long as median suture of prefrontals and about one fourth maximum length of frontonasal; latter rather ovoid, posterior apex a right angle, anterior margin rounded; prefrontals practically as long as frontal, their common median suture about one third the maximum length of the scales; postseminasal considerably elevated, reaching dorsal surfaces of snout and separating prefrontals from preseminasals; frontal hexagonal, width five-sixths of length, the latter dimension (5.4 mm.) five eighths of the distance of the frontal from tip of snout (8 mm.), anterior apex of frontal about 60°, posterior apex about 75°; frontoparietals about twice as long as broad, in contact medially for three-fifths of their length; three parietals, those on the sides slightly larger than the median parietal; a small scale intercalated between median parietal and the two frontoparietals.

Three supraoculars, anterior small and in contact with prefrontal and frontal; second supraocular largest, broadly in contact with frontal, very narrowly with frontoparietal; last supraocular in contact with frontoparietal along nearly one-half of its posterior and median margins; a group of granules posterior to last supraocular, four or five in a series from the postsuperciliaries forward along the parietal and frontoparietal; a single row of granules between supraoculars and superciliaries, the anterior scale largest and in contact with anterior superciliary; latter only twice as long as broad; second superciliary longest, nearly twice as long as anterior; three short posterior superciliaries together a little more than half as long as second superciliary; posterior to these is an irregular group of scales forming about three or four rows, larger than the granules above or below them, extending posteriorly nearly to the dorsal margin of the ear opening, and continuous anteriorly with the postoculars as well as with the superciliaries.

Loreal very large, broadly in contact dorsally with prefrontal and below with the labials; preoculars small, keeled; a keeled frenocular bordered anteriorly by a small scale split off the lower posterior corner of the loreal; sub-

*The specimens cited herewith, in this collection, bear field numbers assigned by H. M. Smith; all are property of the U. S. National Museum and will receive permanent catalogue numbers in that collection.

ocular relative short, keeled from its anterior margin to about the middle; one large postocular, in contact with labials and above it a group of irregular, small postoculars; supralabials 7-7, all in contact with the group of scales described above, and followed posteriorly by a number of small scales bordering the extreme posterior edge of the lip.

Mental large, as broad as long; one postmental, somewhat larger than mental; five large infralabials, the anterior smallest; four large chinshields on either side followed posteriorly by two smaller chinshields; anterior chinshields in contact medially for a short distance; other chinshields separated from infralabials by one or two rows of sublabials of various sizes.

Gulars small, flat, with a median group of distinctly enlarged scales arranged in a single longitudinal series; maximum width of a central gular 3.2 mm.; an anterior gular fold, nearly as well developed as the posterior, with granular scales somewhat larger than those in the posterior; mesoptychials enlarged, the largest nearly as wide (2.6 mm.) as central gular but twice as long (2.9 mm.).

Dorsal scales fine, rounded, imbricate, slightly smaller toward the sides, pointed, not keeled but the tips somewhat elevated, numbering 131 in a transverse row at the middle of the body; ventral plates large, in eight longitudinal series, 37 from gular fold to anus, about 30 to the level of the femoral pore series; preanals in two rows; caudal scales very large, elongate, heavily keeled, except for those on the ventral surface near the base of the tail.

Lamellar formula for fingers 7-12-14-15-11 (?-12-14-16-11); lamellar formula for toes 9-13-17-27-14 (8-15-17-28-14); femoral pores 18-19.

Measurements in mm. are as follows: snout to vent 89, head to posterior border of ear opening 24.8, hind leg 71, tail 187.

Dorsal body ground color dark olive brown; a broad upper lateral light stripe, somewhat bluish in color, extends from the level of the gular fold to the tail; this stripe is eight or nine granules wide and is bordered on both sides by a dark brown zone which gradually merges with the lighter ground color; there is no evidence of the dorsolateral light stripes; the sides of the body are marked with a series of irregular vertical bars which extend dorsally to the level of a line about half way between the arm and the upper lateral light stripe; limbs uniform dark brown above; head uniform dark brown above, lighter on sides; ventral surfaces bluish, the lateral row of belly plates checkered with dark brown; gular region and ventral surface of head bluish cream; ventral surfaces of thigh and shank dark blue; tail bluish, irregularly marked with cream in the anal region, dorsal surface uniform dark brown.

Coloration in adult females. There is a striking sexual dimorphism in the pattern of this form. Adult males are typically marked as described above for the holotype, but adult females completely lack the broad upper lateral stripe so characteristic of the other sex. Like most other forms of the *undulata* group the females possess a narrow dorsolateral light stripe extending from the level of the posterior superciliaries to the tail; its medial border is formed by the body ground color and therefore is not sharply defined, in fact the stripe tends to merge posteriorly with the broad dorsal brown band. The lateral border of the dorsolateral light stripe is very sharply defined, formed by the broad dark brown lateral zones. A lateral light line extends from the level of the upper margin of the ear to the groin; generally this is broken up

into spots throughout a part or all of its length. The ventral surfaces are pale bluish white or bluish cream.

Coloration of the juveniles. Young males lack the broad upper lateral light stripe, but possess the transverse light bars on the sides of the body, and the distinct dorsolateral light stripe. Young females are marked like the adults. In neither sex is there a distinct dark stripe bordering the dorsolateral light stripes medially.

Variation in scutellation. In the entire series of paratypes the femoral pores vary from 14 to 23 in both sexes; in adult males they vary from 15 to 23, average 18, in 28 counts; in adult females they vary from 14 to 19, average 16.4, in 27 counts. The lamellae on the fourth toe vary from 24 to 33 in both sexes; in adult males they vary from 26 to 31, average 28.3, in 27 counts; in adult females they vary from 27 to 33, average 29.3, in 25 counts; the lower counts, of 24 and 25, occur in four young specimens whose sex is not certain. The granules between the superciliaries and supraoculars are arranged in a single row except in two specimens in which there is an additional half row posteriorly, and in a few which have one or two additional scales. Preanals are in two regular rows in all except nine specimens; in eight of these the double series is broken only by a single entire scale in the second row from the anus; the other specimen has two scales in the row next to the anus, and three subequal scales in each of the two preceding rows.

The median gulars are distinctly enlarged in all specimens. In southern specimens they are regularly arranged in a single longitudinal row; the topotypes and two specimens from Matías Romero, which represent the southernmost known localities for this race, all exhibit this condition. Presumably this condition of the gulars is maintained for a considerable distance northward; unfortunately specimens are lacking, however, from localities between the preceding and Cosolapa, Oaxaca; the single specimen from the latter locality has a nearly complete row with only one scale divided. All other specimens are from an area in which the gulars vary to a considerable degree; 11 out of 33 have a perfectly complete median row, four have only a single scale divided, three have only three entire scales in the series, four have only two entire scales in the series, and six have the scales arranged irregularly. In 28 specimens out of 33 the widest gular is wider than the widest mesoptychial, subequal in three, narrower in one, indeterminate in one; and in 29 out of 33 the widest gular is wider than the widest preanal, subequal in three, and narrower in one.

Other scale variation, while extensive in some characters, is not significant as far as we are aware at the present time.

The largest male measures 101 mm. snout to vent, the largest female 92 mm.

Variation in coloration. Adult males possess a pattern which, except for minor variations, is exactly the same as that of the holotype. Its most outstanding feature is the broad upper lateral light stripe. The smallest specimen in which this stripe is continuous measures 75 mm. snout to vent; all specimens measuring 90 mm. or more (five) have the characteristic adult pattern of the race; specimens measuring between 75 and 90 mm. may have the stripe complete (four), or may have the stripe broken into a series of large light spots (three). In still smaller specimens (three whose sex is certain and

measure from 67 to 74 mm.) the stripe is broken and the spots tend to be separated more widely. Apparently the ontogenetic trend in respect to this character is from a pattern perhaps similar to that of the females, in which there is no evidence of an upper lateral light line below the dorsolateral light line; early in life large isolated spots begin to appear and these increase in size, particularly in a longitudinal direction, as the animal grows, until they fuse to form a continuous stripe. At the same time the dorsolateral light stripe tends to disappear, leaving in the largest males no evidence whatever or only a dim remnant in the nuchal region. The vertical light bars on the sides of the body vary greatly in number, size and distinctness; we discern no ontogenetic trends in this marking. In some specimens the sides are almost uniform brown with only a few small scattered light spots, while others are very strikingly marked. In none except the young, do the lateral bars reach the level of the upper lateral light stripe. Since the upper lateral light stripe occurs in the lateral dark field below the level of the dorsolateral light stripe, in most specimens it is seen to be bordered medially by a narrow longitudinal dark stripe; this is not to be interpreted as homologous with the similar stripe of the related race *u. stuarti,* since in the latter the dark stripe actually borders the *dorsolateral* light stripe instead of the *upper lateral* light stripe. The broad dorsal area between the region of the dorsolateral light stripes may be uniform brown or as in many specimens may be marked with irregular transverse spots which tend to form a series on either side; these spots seldom, if ever, cross the middorsal line. In some specimens the tail has a distinct checkered pattern of small dark spots. The sides of the belly vary somewhat in amount of checkering.

The typical pattern of adult females has already been described. There is relatively little ontogenetic change (contrary to the situation in males); the young differ very little from the adults. A distinct dorsolateral light stripe is present throughout life, although in some specimens on the posterior part of the body it may tend to merge with the dorsal ground color; invariably the stripes are clearly evident in the nuchal region and in all specimens they are more distinct there than elsewhere. The upper tips of the lateral vertical light bars most characteristic of the males is represented in the females by a longitudinal series of small rounded light spots usually completely isolated from all other spots; this series extends from the upper margin of the tympanum to the groin and may form in some a quite or nearly continuous light line. There is no ontogenetic trend in this feature as far as we are aware. The remainder of the vertical bars of the males may be completely absent or represented by scattered light spots or even, in some cases, by dim vertical bars; the typical condition is for there to be few or no scattered light spots below the lateral light line. In the very largest specimens (about 85 or 90 mm. in length or over) there is a tendency to form upper lateral light streaks between the dorsolateral and lateral light lines; these are homologous to the upper lateral light streaks so characteristic of the male. In the females, however, they are extremely weakly developed, appearing either as a vague lighter zone or as a series of extremely dim lighter spots. As in the males there is a tendency to form a series of dark marks on either side of the broad middorsal brown zone adjacent to the dorsolateral light stripes. We find no evidence whatever of these marks in young specimens (31 to 62 mm.

in length, six specimens); they are feebly developed in subadults (ten specimens, 65 to 85 mm. in length) but in larger specimens they may become very prominent or even tend to form a longitudinal dark stripe bordering the dorsolateral light stripes medially. Such dark stripes, however, are of rare occurrence, and do occur only as a final phase in the ontogenesis of pattern; therefore this is not to be construed as a feature comparable to the similar marking in *u. stuarti*, since in that form the dark stripes are best developed in the young and may or may not disappear in the adult.

Comparisons. By the possession of two rows of preanals, the present subspecies differs from *u. undulata.* From *u. hartwegi* it differs markedly in the size of the median gulars. There is little relationship with *u. parva* which has two rows of granules between the supraoculars and the superciliaries. From all three of these forms *u. amphigramma* differs markedly in pattern, particularly of the males.

The only other form of this species described from Mexico is *u. stuarti*, to which *u. amphigramma* is probably most closely related. Like it the latter form has two rows of preanals and a single row of enlarged median gulars. The difference between the two forms lies exclusively in pattern, at least so far as we are aware. In *u. stuarti* a dark stripe (paradorsolateral) borders the dorsolateral light line on its median edge; this stripe is well developed and easily visible in all young specimens regardless of sex, and is typically retained in adult females; in males it generally disappears in adults, but there is no tendency whatever, to develop an upper lateral light line. In *u. amphigramma* there is no dark line as described for *u. stuarti* except in rare adult females, and males possess a conspicuous upper lateral light line.

Distribution. Ameiva undulata amphigramma is in contact apparently with only *u. stuarti*, which borders it on the south in southern Veracruz. The northernmost locality for the latter race is Rodríguez Clara, Veracruz, from which locality four specimens are available; three are juveniles and possess the paradorsolateral dark stripes typical of *u. stuarti*, and the other is an adult female lacking the stripe. The southernmost specimens of *u. amphigramma* are from Matías Romero, Oaxaca, and from the type locality, San Andrés Tuxtla, Veracruz. The latter locality is only a relatively short distance north of Rodríguez Clara and may possibly prove to be within an area of intergradation between the two races. All topotypes are, however, fully typical of their race as we understand it.

The two specimens from Matías Romero are juveniles, one measuring 31 mm., the other 43 mm. from snout to vent; they lack the paradorsolateral dark stripes which without exception are present in juveniles of *u. stuarti;* accordingly we do not hesitate to associate them with *u. amphigramma.* In spite of the proximity of this locality to the range of *u. undulata* there is no similarity to that form apparent in these specimens. It is suggested that *u. undulata* may intergrade with *u. amphigramma* instead of with *u. stuarti* as previously thought.

All other specimens available of *u. amphigramma* come from a relatively restricted area in Veracruz between the city of Veracruz, Jalapa and some 30 miles south of Córdoba. While the pattern of all specimens is typical we believe that the variable nature of the gular scales may be indicative of intergradation with a northern form which lacks the upper lateral light stripe and

typically has irregular gulars. We assume, therefore, that the typical condition for the bulk of the populations of *u. amphigramma* between the area of intergradation with *u. stuarti* in southern Veracruz and that in central Veracruz with the northern form is to have a single median row of enlarged gulars. Evidence, however, is inconclusive. It may well be that throughout the entire range of *u amphigramma* the gulars are irregularly arranged.

Cnemidophorus deppii deppii Wiegmann

Two specimens (Nos. 830, 832) are from Río Aguacatillo, 30 kilometers north of Acapulco, Guerrero, collected by W. B. Davis and M. H. Whisenhunt, August 6-8, 1942. Both are adult males.

Respectively, certain scale counts are: preanal rows 4, 4; femoral pores 18-19, 19-21; circumorbitals 7-7, 8-12; rows of granular scales between supraoculars and superciliaries 1-1, 2-2;* lamellae on 4th toe, 30-30, 28-29; frenocular separated from loreal on one side in No. 832; preoculars 1-1, 1-1. The entire belly is black, and the throat is heavily suffused with gray. The dorsal surface is uniformly striped.

These adult males verify the previously tentative conclusion that the *deppii* population in the vicinity of Acapulco belong to the typical race (Smith, 1944, pp. 90-91); previously reported specimens have been immature. The coloration of adult males is of prime importance in distinguishing *d. deppii* and *d. lineatissimus*. The present two are completely typical of the former in this respect Likewise the femoral pore counts are typical; it is possible that the lowness of the counts of the specimens previously reported is due to immaturity.

Cnemidophorus gularis gularis Baird and Girard

Ten specimens are in the collection: *Nuevo León*: 13 miles southwest of Sabinas Hidalgo, June 17, 1941, W. B. Davis (Nos. 786-792); Río Ramos, 20 kilometers northwest of Monterrey, R. L. Peterson, June 19, 1941, and M. H. Whisenhunt, June 16, 1942 (Nos. 652, 863). *Tamaulipas*: Alicia, 60 miles south of Victoria, July 13, 1941, W. B. Davis (No. 695).

All are typical adults; males have pink throats and uniformly dark bellies.

Cnemidophorus guttatus guttatus Wiegmann

The collection contains 17 specimens, all from Veracruz. Ten (Nos. 765, 766, 768-774, 777) are from Puente Nacional, collected by R. L. Peterson on July 6, 7, 1941. The rest are from Boca del Río, 10 feet, collected by W. B. Davis, July 20, 1942 (No. 835) and by M. H. Whisenhunt, July 21, 1942 (Nos. 823, 824, 826-829).

Variational data included in the accompanying table may be summarized as follows: in 12 males the femoral pores vary from 18 to 22, average 20.4; lamellae on the 4th toe 31 to 37, average 33.8; preanal scale rows 8 to 13, average 9.7; circumorbital scales 5 to 10, average 8. In five females the femoral pores vary from 19 to 24, average 20.8; lamellae on the 4th toe 32 to 37, average 34.8; preanal scale rows 8 to 11, average 9.4; circumorbital scales 6 to 10, average 8.5.

So far as can be determined with the material at hand, which is somewhat discolored by formaldehyde, there is little difference in dorsal pattern between

*In No. 830 on one side there are a few extra scales; in No. 832 neither side has two complete rows, although they are very nearly complete.

the sexes; however, it does appear that in females the dorsal spots are more numerous and smaller, and that the lateral dark stripe persists longer. The ventral markings are essentially the same in juveniles of both sexes; most of the ventral surfaces, including the throat and collar, are black or deeply suffused with gray. In females this coloration is retained throughout life; generally there is a vague lighter streak down the middle of the abdomen. In males, however, the belly and collar become uniform black and the gular region in front of the collar becomes conspicuously lighter and is, probably, suffused with orange in life. In all specimens, young or adult, the granular area concealed by the gular collar is light.

VARIATION IN SCALE COUNTS OF *Cnemidophorus g. guttatus*

Number	Sex	Circum-orbitals	Preanal Scale Rows	Femoral Pores	Lamellae on 4th Toe
766	♂	7	10	21-22	37-36
835	♂	8	9	19-20	33-34
765	♀	6	11	24-?	35-36
772	♂	5	10	21-22	32-33
774	♂	9	7	19-?	34-34
769	♂	6	11	20-20	36-34
773	♀	—	9	19-19	34-32
771	♂	9	9	19-20	33-34
770	♂	8	11	21-21	34-35
829	♂	10	10	22-22	33-34
826	♂	7	9	19-20	33-33
828	♀	10	9	21-19	36-?
823	♂	10	13	21-22	32-34
824	♀	9	10	21-21	37-35
768	♀	9	8	21-22	34-34
827	♂	9	10	20-21	37-34
777	♂	8	8	18-19	31-?

In general the dorsal pattern is relatively obscure in both sexes and consists of small, usually rounded, but sometimes transversely elongate, light spots arranged in indistinct longitudinal series and dispersed upon a dull, brownish gray background. In no specimens are the spots in the middorsal area connected to form longitudinal or transverse lines; however, in the very young the dorsolateral series of spots may form a nearly continuous line, while the lateral series form an unbroken line; these 2 lines are retained to varying degrees in the adults, but generally disappear.

Cnemidophorus guttatus immutabilis Cope

A single male specimen (No. 831) from Río Aguacatillo, 1,000 feet, 30 kilometers north of Acapulco, Guerrero, was collected by W. B. Davis on August 8, 1942.

Femoral pores 21-23, preanal scale rows 10, circumorbital scales 11, lamellae on 4th toe 34-34. The specimen is markedly different from those of *g. guttatus;* the light dorsal markings are very well defined and consist of numerous stripes, the middorsal ones of which are broken into large spots. There is a tendency toward the formation of a middorsal light stripe.

We agree with Hartweg and Oliver (1939:3-7) that the Atlantic and Pacific coast forms of *guttatus* are recognizably distinct.

Gerrhonotus imbricatus Wiegmann

The collection contains 18 specimens as follows: seven from Monte Río Frío,, 45 kilometers east southeast of Mexico City México, of which four

(Nos. 740-743) were collected by W. B. Davis on June 25, 28, 29, 30, 1941, one (No. 738) by R. L. Peterson on June 26, 1941, one (No. 739) by E. L. Rollins, and one (No. 711) by R. L. Haines on June 29, 1941; eight from 55 kilometers southeast of Mexico City, México, 10,500 feet, of which five (Nos. 911-915) were collected by W. H. Whisenhunt on July 2, 9, 1942, and three (Nos. 916-918) by S. H. Wheeler on July 2, 1942; two from 45 kilometers southwest of Mexico City, México, 9,400 feet, collected on August 11, 14, 1942, by E. Powell (No. 919) and S. Stegall (No. 920); and one from Río Otlati, 15 kilometers northwest of San Martín, Puebla, 8,700 feet, collected by W. B. Davis and group on August 1, 1942 (No. 901)).

The dorsals, from interparietal to base of tail, vary from 38 to 44 (38, two; 39, five; 40, four; 41, three; 42, two; 43, one; 44, one). The dorsal scale rows vary somewhat but the usual number, 14, occurs in 15 specimens. One specimen has one outer scale row on each side considerably reduced so that the rows could be counted as either 12 or 14; one specimen has 15, and another 16 rows.

The dorsal head scales are in general normal in all specimens, there being the usual three pairs of scales between the rostral and frontal, two outer supraoculars, four inner supraoculars, two frontoparietals, etc.; in one specimen the lateral corner of the internasal is split off as a separate scale; in another the frontal is fused with one reduced frontoparietal and the third supraocular is in contact on that side with the interparietal. Typically one large postnasal contacts the supranasal; in one anomalous specimen, however, there is no postnasal on one side (probably fused with the loreal), and in another the supranasal is absent on one side allowing the nasal narrowly to contact an internasal while the postnasal contacts the posterior internasal.

Leptotyphlops myopica myopica (Garman)

Two specimens (Nos. 653, 885) are from Río Ramos, 20 kilometers northwest of Montemorelos, Nuevo León, 1,000 feet, R. L. Peterson and M. H. Whisenhunt, June 20, 1941, and August 30, 1942, respectively.

The scale counts and measurements are as follows, respectively: dorsals 223, 218; subcaudals 13; scales around tail 10; around body 14; total length 196 mm., 182 mm.; tail length 10 mm., 9 mm. Two supralabials precede the ocular.

Constrictor constrictor imperator (Daudin)

A single female specimen (No. 921) is from Puente Nacional, Veracruz, R. L. Peterson, July 7, 1941. The scale rows are 53-67-37, the caudals 51; total length 1408 mm., tail 138 mm. The ventrals cannot be counted.

Coniophanes fissidens proterops Cope

A single male specimen (No. 890) is from 5 kilometers north of Jalapa, Veracruz, 4,500 feet, B. Leftwich, August 5, 1942.

The scale counts and measurements are as follows: scale rows 19-19-15, ventrals 127, caudals 63, supralabials 6-7, infralabials 8-9, preoculars 1-1, postoculars 2-2, temporals 1-2-3; total length 208 mm., tail length 44. Small flecks of black color are present near the ends of the ventrals, and an increasing number toward the throat. The sides of the body are not darker than the

middorsum, except near the tail, where a dorsolateral darker stripe is faintly evident; the stripe extends onto the tail.

The specimen agrees completely with the characters of this race (Smith, 1941:105-106).

Drymobius margaritiferus margaritiferus (Schlegel)

One specimen (No. 880) is from Río Ramos, 20 kilometers northwest of Montemorelos, Nuevo León, 1,000 feet, M. H. Whisenhunt, June 4, 1942.

The specimen is a typical male with 17-17-15 scale rows, 144 ventrals, 111 caudals, 9-9 supralabials, 10-10 infralabials, 1-1 preoculars, 2-2 postoculars, and 2-2 temporals; total length 904 mm., tail length 329 mm.

Drymobius margaritiferus fistulosus Smith

One specimen (No. 881) is from Río Aguacatillo, 30 kilometers north of Acapulco, Guerrero, 1,000 feet, D. H. Buck, August 4, 1942.

The specimen is a male with 17-17-15 scale rows, 158 ventrals, 59+ caudals, 9-9 supralabials, 10-10 infralabials, 1-1 preoculars, 2-2 postoculars, 2-2 temporals; total length 725 mm.+, tail length 81 mm.+. The light dorsal spots on the body are small and closed anteriorly by black as is typical of this race (Smith, 1942:383-384).

Lampropeltis triangulum arcifera (Werner)

A single female specimen (No. 692) is from 5 kilometers north of Jalapa, Veracruz, W. H. Bunger, July 3, 1941.

The scale counts and measurements are as follows: scale rows 21-19-17; ventrals 242; caudals 46; supralabials 7-7; infralabials 9-8; preoculars 1-1; postoculars 2-2; temporals 2-3; total length 845 mm., tail length 130 mm. The pattern is typical (Smith, 1942:198-199, pl. 1, Fig. 1), consisting of 24 white rings on the body, each bordered by a pair of black rings each in turn as long as or longer than the adjacent red bands, except for two near the posterior end of the body. The scales in the red areas are tipped with black.

Lampropeltis triangulum polyzona Cope

A single female specimen (No. 894) is from five kilometers north of Jalapa, Veracruz, 4,500 feet, W. B. Davis, August 4, 1942.

The scale counts and measurements are as follows: scale rows 21-21-17; ventrals 212; caudals 48; supralabials 7-8; infralabials 8-8; preoculars 1-1; postoculars 2-2; temporals 2-3; total length 876 mm., tail length 133 mm. There are 24 light rings on the body, including that about the nape; only four red rings are less than twice as long as the adjacent black rings, and of them only one is reduced to a length equal to that of the adjacent black rings. This pattern is typical of that of *polyzona*.

Our reference of the only two available specimens of *Lampropeltis triangulum*, presumably from the same locality, to different subspecies, is not, we realize, entirely satisfactory. This interpretation can be correct literally only if it is proved that the two subspecies concerned have strict ecological limitations to different habitats occurring within a relatively small area five kilometers north of Jalapa. According to Davis (1943:373) this locality actually is "rain forest-arid tropical transition" in character, and in this respect the requirements to support our premise are met. However, only

further collecting can indicate whether individuals of the two forms actually do maintain ecological independence.

There is a strong possibility, on the other hand, that this locality is within the area of intergradation between the two races; that a large series from there would include a wide variety of pattern; and that the present specimens merely represent two extremes. Even were this alternative correct, however, in the present case it would be impossible to state with which form these two specimens should be allocated, since each appears typical of its own particular pattern type.

Leptodeira maculata (Hallowell)

A single female specimen (No. 884) is from Río Axtla, San Luis Potosí, 200 feet, M. H. Whisenhunt, June, 1942.

The scale counts and measurements are as follows: scale rows 21-23-17, ventrals 170, caudals 55, supralabials 8-8, infralabials 9-10, preoculars 1-1, postoculars 2-2, and temporals 1-2-3; total length 544 mm., tail length 102 mm. Dark bands on body 26, on tail 7; the light neck collar is complete; the head is uniform dark brown except for light edges on certain scales; the ventral surfaces are unpigmented.

The specimen is quite typical and shows no approach toward *Leptodeira annulata taylori* or *L. a. septentrionalis.*

Pituophis deppei deppei (Duméril)

A single female specimen (No. 883) is from 23 kilometers east of Mexico City, México, 7,500 feet, E. W. Bonn, August 9, 1942.

The scale counts and measurements are as follows: scale rows 25-29-23, ventrals 224, caudals 5-5, supralabials 8-9, infralabials 11-12, internasals 2, preoculars 1-1, postoculars 2-3, temporals 2-4; total length 497 mm., tail length 130 mm. There are 39 dark blotches on the body, 12 on the tail. The anterior and posterior blotches are black, the others brown and dark edged.

Salvadora lineata Schmidt

A single specimen (No. 1021B) is from Río Ramos, 20 kilometers northwest of Montemorelos, Nuevo León, 1,000 feet, W. B. Davis, June 8, 1942.

The specimen is a sub-adult male, with the extreme tip of the tail missing, but otherwise in perfect condition. The pattern is typical of the species as described and figured by Smith (1941:5, Fig. 4). The rostral is somewhat enlarged and has slightly free edges, as is typical; preseminasal very narrowly in contact with second supralabial; postseminasal in contact only with second supralabial; one loreal, in contact with second and third supralabials; two preoculars, lower in contact with third and fourth supralabials, upper with none; fourth and fifth supralabials entering orbit; two postoculars, lower very narrowly in contact with sixth supralabial on one side, while on the other side the fifth supralabial and lower anterior temporal join it and the sixth supralabial at a common point. Supralabials 8-8; infralabials 10-10; posterior chin shields widely separated; a very small upper primary temporal; 10 + 3 maxillary teeth; scale rows 17-17-13; ventrals 191; caudals 80+; total length 815 mm.+; tail length 198 mm.+.

Tantilla bocourti deviatrix Barbour

A single male specimen (No. 700) is from 26 kilometers east of Zimapán, Hidalgo, R. L. Peterson, July 12, 1941.

The scale counts and measurements are as follows: scale rows 15-15-15, ventrals 164, caudals 47+, supralabials 7-7; infralabials 6-6, preoculars 1-1, postoculars 2-2, and temporals 1-2; total length 396 mm.+, tail length 81 mm.+.

The head is very light, the dark brown areas being greatly reduced and chiefly in evidence in the parietal region; the remainder of the top of the head is brownish like the back; the dark color likewise does not reach the lip on one side, and only feebly on the other; all the dark areas are mottled and irregular in character. The lower jaw has a few discrete dark marks.

Three characters distinguish *bocourti* and *deviatrix*: shape of temporal, number of ventrals, and color of head. The present specimen clearly has the head color of *deviatrix;* in *bocourti* the top and sides of head are uniform black or dark brown except for small areas on the snout and behind the eye. It has more ventrals than have been recorded up to the present in *deviatrix,* but the previously established range is obviously incomplete, since (1) only two specimens of the latter species are known, and (2) the range as known in the past (154 to 160) is too small in comparison with the ranges of variation in other species of *Tantilla.* To include the count of the present specimen with the others of *deviatrix* still does not expand the range of variation unduly; further expansion is to be expected. Thus the specimen can be said to agree with either *bocourti* or *deviatrix* in ventral count. Finally, the character of the temporal is clearly that of *bocourti;* however, it is known that some variation does occur in this feature, which is not to be considered as significant as the coloration. Thus we associate this specimen with *deviatrix.*

Locality records of typical *bocourti* (Smith, 1942:34-35) indicate a range from Mirador (central Veracruz) southward through southern Puebla to the Tehuacán region, northwestward through Distrito Federal and Guanajuato (city), and thence westward and southward over most of the elevated areas in the states of Guerrero, Michoacán, Jalisco, México and Guanajuato. The form thus avoids, for the most part, the valleys of central Hidalgo northwestward to southern San Luis Potosí, an area in which *deviatrix* probably is the typical form. However specimens of the latter have been known only from southern San Luis Potosí; the present one is from a locality intermediate between that area and the known range of typical *bocourti* in Puebla and Veracruz. Since it is intermediate in character, as well as being from an intermediate locality, we believe the indication of intergradation between these two forms is fairly clear. Hartweg (1944:7-8) reports a specimen which likewise is intermediate, having the ventrals of *deviatrix* (160) but the temporal and head pattern of *bocourti.* Unfortunately it bears the indefinite locality "Puebla", from which state only typical *bocourti* is known, and whether the specimen was to be considered a variant of *bocourti* or an intergrade was not evident, although Hartweg, correctly we now believe, thought that it "appears to be an intergrade and probably indicates subspecific ranking for *bocourti* and for *deviatrix.*" Regarded as an intergrade (as we do here), the Puebla specimen, if indeed from that state, perhaps was collected in the northern, desert portions of the state, in the basin that extends northwestward into central northern Mexico. At its southern end this basin is, apparently, populated by intergrades closely approaching *bocourti bocourti* in character; in central Hidalgo by intergrades closely approaching *bocourti deviatrix* in char-

acter; and in southern San Luis Potosí by typical *bocourti deviatrix*. Typical *bocourti* caps the southern tip of the range of *b. deviatrix*, and borders it on the west as far north as Guanajuato. Whether intergradation occurs in adjacent portions of the ranges of the two forms along the line between Mexico City and Guanajuato is dubious; the very high counts of *b. bocourti* in that area indicate that it does not.

Toluca lineata lineata Kennicott

A single specimen (No. 868) is from a locality 13 kilometers northeast of Tlaxcala, 7,800 feet, Tlaxcala, R. R. Rusche, July 21, 1942.

Ventrals 125; caudals 28; supralabials and infralabials 7-7; preoculars 1-1, in contact with second supralabial; postoculars 2-2; loreals 1-1; internasals normal, paired; total length 212 mm.; tail length 33 mm.; pattern not discernible.

Toluca lineata wetmorei Smith

Of two specimens, one (No. 776) is from a locality 25 miles north of Jalapa, Veracruz, J. L. Robertson, July 9, 1941; the other (No. 943) is from 5 kilometers east of Las Vigas, 8,000 feet, Veracruz, W. B. Davis, August 1, 1942.

Both specimens are males whose counts and measurements (in mm.) are as follows, respectively: ventrals 122, 120; caudals 28+, 38; supralabials 7-7, 7-7; infralabials 6-7, 6-6; preoculars 1-1, 1-1; postoculars 2-2, 2-2; loreal 1-1, 0-0; temporals uniformly 1-2-3; total length 257+, 110; tail length 42+, 45.

In No. 776, the preocular is narrowly separated from the second supralabial on one side. The internasals are normal in both specimens.

Natrix rhombifera blanchardi Clay

Two specimens (Nos. 864, 882) are from Río Ramos, 20 kilometers northwest of Montemorelos, 1,000 feet, Nuevo León, M. H. Whisenhunt, June 5, 28, 1942.

The scale counts and measurements of these specimens are, respectively: scale rows 23-25-17, 25-25-19; ventrals 143, 147; caudals ?, 69; supralabials 8-8, 8-8; infralabials 10-10, 9-10; preoculars 1-1, postoculars 3-3, temporals 1-2, in each; total length 904 mm.+, 965 mm.; tail length 200 mm.+, 222 mm.; sex ♂, ♀. The pattern is almost nonexistent; the dorsal spots are not discernible and the belly is completely unmarked. Even the subcaudal surface is uniformly unspotted (Clay, 1938:251-253, pl. 25).

Storeria dekayi temporalineata Trapido

One specimen (No. 889) is from five kilometers north of Jalapa, Veracruz, 4,500 feet, M. H. Whisenhunt, August 1, 1942.

The specimen is a very small female measuring 103 mm. in total length, tail length 22 mm.; scale rows 17-17-17, ventrals 134, caudals 49, supralabials and infralabials 7-7, preoculars 1-1, postoculars 2-2, and temporals 1-2. The temporal marking is not evident but we allocate this specimen with *temporalineata* for geographic reasons (Trapido 1944: 70-73, Figs. 51, 52).

Storeria dekayi texana Trapido

One specimen (No. 888) is from Río Ramos, 20 kilometers northwest of Montemorelos, Nuevo León, 1,000 feet, M. H. Whisenhunt, August 30, 1942.

The specimen is a typical male with 17-17-17 scale rows, 127 ventrals, 52 caudals, 7-7 supralabials and infralabials, 1-1 preoculars, 1-2 postoculars, and 1-2 temporals; total length 261 mm., tail length 53 mm. The anterior temporal is unmarked. The specimen agrees with Trapido's diagnosis (Trapido 1944:63-70, Figs. 45-50).

Storeria storeroides (Cope)

The collection contains five specimens (Nos. 886, 887, 895-897), all from 55 kilometers southeast of Mexico City, México, M. H. Whisenhunt, July 2, 9, 12, 1942.

The scale counts and measurements (in mm.) are, respectively: ventrals 127, 134, 136, 131, 133; caudals 41 (♀), 43 (♀), 46 (♀), 47 (♂), 52 (♂); supralabials 8-8 in No. 886, 7-7 in others; infralabials 6-? in No. 886, 7-7 in others; preoculars 1-2 in No. 886, 2-2 in others, postoculars 2-2; temporals 1-2, 1-1, 1-2/1-3, 1-2; total length 220, 330, 368, 326, 341; tail length 39, 64, 75, 68, and 75.

The specimens appear typical in all respects, save that two exceed the size limits previously known: No. 897, a male, is 13 mm. longer than the maximum recorded by Trapido (1944:9), and No. 895, a female, is 28 mm. longer.

Thamnophis eques eques (Reuss)

The collection contains four specimens as follows: two (Nos. 866, 872) from 5 kilometers east of Las Vigas, Veracruz, 8,000 feet, W. B. Davis and S. H. Wheeler, August 3, 1942; one (No. 873) from 45 kilometers southwest of Mexico City, México, 9,400 feet, E. Powell, August 18, 1942; and one (No. 891) from 23 kilometers east of Mexico City, México, 7,500 feet, E. Powell, August 3, 1942.

The scale counts and measurements (in mm.) are as follows, respectively: scale rows 19-19-17, preoculars 1-1, postoculars 3-3, in all; ventrals 158, 151, 157 and 152; caudals 63 (♀), 57+ (♀), 68 (♀) and 40+ (♂); supralabials 7-7, 6-6, 7-7 and 8-8; infralabials 10-10, 9-9, 10-10 and 9-10; temporals 1-2, 1-2, 1-2 and 1-2/3; total length 269, 231+ 383 and 454+; tail length 59, 41+, 98 and 70+.

The color pattern is typical, as is the scutellation except for the number of caudals in one female (No. 866) which has five less than the previously recorded minimum (Smith 1942:106).

Thamnophis macrostemma macrostemma (Kennicott)

Three specimens (Nos. 869, 877, 878) are from a locality 8 kilometers southwest of Tlaxcala, 7,500 feet, Tlaxcala, R. R. Rusche, July 24, 1942.

The scale counts and measurements (in mm.) are as follows, respectively: scale rows 19-21-17 throughout; ventrals 158, 158, 155; caudals 60+ (♀), 60 (♀), 60 (♂); supralabials 8-8, 8-8, 7-8; infralabials 8-8; preoculars 1-1; postoculars 3-3; total length 181+, 500, 639; tail length 34+, 101, 125. The pattern is not discernible.

This species has not hitherto been reported from the state of Tlaxcala.

Thamnophis sauritus proximus (Say)

Three specimens are present: one (No. 865) is from a locality five kilometers east of Las Vigas, 8,000 feet, Veracruz, W. B. Davis, August 3, 1942;

the other two (Nos. 870, 871) are from Río Ramos, 20 kilometers northwest of Montemorelos, Nuevo León, 1,000 feet, M. H. Whisenhunt, June 5, 13, 1942.

All are males with the following scale counts and measurements (in mm.), respectively: scale rows uniformly 19-19-17; ventrals 172, 162, 166; caudals 107, 66+, ?; supralabials 8-8; infralabials 9-9; preoculars 1-1; postoculars 3-3; temporals 1-2; total length 610, 478+, ?; tail length 190, 114+, ?. The snout-vent length in No. 871 is 419 mm.

Las Vigas is a locality near the extreme southern periphery of the range of this subspecies; apparently this form may range a considerable distance southward along the Sierra Madre Oriental beyond the northern limits of the range of *sauritus chalceus,* which parallels the former but is restricted to the coastal plain and its vicinity.

Thamnophis scalaris scalaris Cope

The collection contains five specimens, four (Nos. 874-876, 892) from 45 kilometers southwest of Mexico City, México, 9,400 feet, E. W. Bonn, E. M. Talk and E. Powell, August 18-19, 1942; and one (No. 893) from 16 kilometers north northeast of San Andrés, west slope of Orizaba volcano, Puebla, 11,000 feet, J. M. Vajdos, August 17, 1942.

The scale counts and measurements (in mm.) are as follows, respectively: scale rows 17-19-15, 15-(17)-15-13, 19-19-17, 17-19-17, 19-19-17; ventrals 137, 140, 138, 140, 139; caudals 56 (♀), 72 (♂), 66 (♂), 56 (♀), 74 (♂); supralabials 7-8, 7-7, 7-7, 8-8, 7-8; infralabials 9-9, 9-9, 9-9, 10-10, 11-11; preoculars 1-1, postoculars 3-3, temporals 1-2 in all; total length 367, 404, 384, 613, 452; tail length 85, 122, 113, 133 and 137.

These specimens vary somewhat from the percentages given by Smith (1942:104) for characters separating *s. scalaris* and *s. scaliger.* His recorded percentages are 70% with the posterior scale rows less than 17 (40% in ours); 93% with anterior scale rows reduced to 17 (60% in ours); 100% with caudals in males over 60 (100% in ours); and 93% with ventrals in males 142 or less (100% in ours).

Thamnophis scalaris scaliger (Jan)

Three specimens are in the collection; one (No. 709) from Monte Río Frío, 45 kilometers east southeast of Mexico City, México, W. Bunger, June 26, 1941; one (No. 898) from 55 kilometers east southeast of Mexico City, México, 10,500 feet, M. H. Whisenhunt, July 12, 1942; and one (No. 879) from 8 kilometers southwest of Tlaxcala, Tlaxcala, 7,500 feet, R. R. Rusche, July 24, 1942.

The scale counts and measurements (in mm.) are as follows, respectively: scale rows 19-19-17 in all; ventrals 139, 150, 147; caudals 62 (♀), 61 (♀), 59 (♂); supralabials 7-8, 7-7, 8-8; infralabials 11-11, preoculars 1-1; postoculars 3-3 in all; temporals 1-2, 1-3, 1-2; total length 424, 325 and 428; tail length 92, 74 and 107. The counts of these specimens are in close accordance with those cited by Smith (*loc. cit.*).

Sistrurus ravus (Cope)

Three specimens are from the following localities: one (No. 861) from 55 kilometers east of Mexico City, México, 9,050 feet, E. Powell, August 12, 1942; one (No. 862) from Lago Salado near Alchichica, Puebla, 8,300 feet,

S. H. Wheeler, July 25, 1942; and one (No. 821) from 8 kilometers southwest of Tlaxcala, Tlaxcala, 7,500 feet, H. L. Gilbert, July 26, 1942.

The scale counts and measurements (in mm.) are as follows, respectively: scale rows 23-21-17, 21-21-17 and ?-21-17; ventrals 145, 149 and ?; caudals 28 (♂), 23 (♀), and 22 (♀); supralabials 12-13, 10-10 and ?; infralabials 11-11, 10-11 and ?. Total length 664, 435 and 195; tail length 67, 32 and 14. The dark dorsal blotches number 35 in No. 861 and 28 in No. 862. The belly is light in the former, dark and mottled in the latter.

The specimen from Tlaxcala constitutes a new record for the state.

Crotalus gloydi lautus Smith

A single specimen (No. 822) is a paratopotype (Smith, 1945) from Lago Salado, near Alchichica, Puebla, 8,300 feet, S. H. Wheeler, July 25, 1942.

Crotalus triseriatus anahuacus Gloyd

Five specimens are from the following localities: one (No. 710) from Monte Río Frío, 47 kilometers southeast of Mexico City, México, R. L. Haines, June 25, 1941; one (No. 819) from 45 kilometers southwest of Mexico City, México, 9,400 feet, E. Powell, August 13, 1942; one (No. 820) from 10 kilometers southeast of Perote, on the northwestern slope of Cofre de Perote, Veracruz, 10,500 feet, L. Follansbee, July 23, 1942; and two (Nos. 859, 860) are from 55 kilometers southeast of Mexico City, México, 10,500 feet, M. H. Whisenhunt, July 2-3, 1942.

The scale counts and measurements (in mm.) are as follows, respectively: scale rows 25-23-19, 25-23-19, 25-23-17, 23-23-17, 25-23-19; ventrals 139, 141, 145, 136, 148; caudals 29 (♂), 31 (♂), 24 (♂), 30 (♂), 25 (♀); supralabials 11-11, 11-12, 12-12, 11-12, 13-15; infralabials 11-12, 12-12, 12-13, 11-12, 13-14; body spots ?, 46, 46, 48±, 47±; tail length 56, 34, 45, 49, 45.

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The Stratigraphic Range of the Pennsylvanian-Permian Disconformity in Pottawatomie County, Kansas

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ABSTRACT

The Indian Cave sandstone is regarded by Moore to be the basal member of the Permian system of rocks. Its stratigraphic range has been estimated at about 100 feet, or the distance from the Brownville limestone to the Dover limestone.

In the area covered by this paper, the sandstone was found at a horizon just above the Wakarusa limestone which lies about 150 feet below the Dover. This survey extends the previous stratigraphic extent of the Indian Cave sandstone from about 100 feet to approximately 250 feet.

INTRODUCTION

The Indian Cave sandstone formation was named by Moore and Moss[1] in 1933 from exposures near Indian Cave, Nebraska. It was their opinion that this formation represents channel fillings in the Wabaunsee group of Pennsylvanian Sediments.

Jewett[2] has observed the Indian Cave sandstone as far south as Cedar Vale, Kansas. In Riley County he found the base of the member occupying stratigraphic positions from approximately the Brownville limestone horizon down to the Dover limestone.

According to Moore[3,4] the Indian Cave sandstone extends downward eighty to one hundred and twenty-five feet from about the horizon of the Brownville limestone. He has observed at least five areas in which the Indian Cave sandstone is well developed. These areas are found from Peru, Nebraska, southward into Oklahoma.

Observations made in Pottawatomie County indicate that the Indian Cave sandstone extends considerably lower stratigraphically than had been previously noted. As a result of these observations, a detailed survey of this area was made to ascertain the exact stratigraphic limits of the formation.

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Location and Description of the Area

The area studied lies in Pottawatomie county near the town of Wamego, Kansas. The base line of the survey extends from the center of section 12—T10S—R9E eastward along the half section line across section 7 and about a fourth of the way into section 8—T10S—R10E. The total length of the base line is about two miles.

Although the area lies within the glaciated region of Kansas, bedrock outcrops are relatively abundant. Good exposures of Indian Cave sandstone were found all along the banks of Cat creek which crosses highway U. S. 24 just west of Wamego. At one locality large blocks of the Tarkio limestone were found embedded in the sandstone. These blocks of limestone represent masses that had slumped into a pre-Permian stream channel at the time the sandstone was being deposited. Other excellent outcrops of Indian Cave occur along the section roads, and along minor stream valleys. The minor streams flow down the relatively steep north wall of the Kaw River valley. Because of their steep gradients they have cut the area into a series of deep N-S valleys in which sediments ranging from the Dover to the Wakarusa limestones are exposed.

Investigational Procedure

A thorough reconnoissance of the area was conducted for the purpose of determining the lithologic characteristics and the stratigraphic intervals between the various formations in the area. The information thus obtained was used in the construction of the columnar section (Fig. 1). At the time of the reconnoissance, the best location for the base line of the survey was chosen.

The area was mapped by means of a plane table and telescopic alidade. Structural contours were drawn using the base of the Tarkio limestone as the datum plane (Fig. 1, plan view). Elevations were determined every one hundred feet along the base line to insure vertical control of the drill borings.

The profile—structure section (Fig. 1) was developed by plotting the elevations along the base line and the elevations of structural contours which crossed the base line. Elevations of formations other than the Tarkio were also plotted on the profile, both from outcrops along the base line and from interpolations based on the structural plan. Drill borings were made at the places where conformable bed rock contacts were obscured by glacial sediment or by the disconformable Indian Cave sandstone.

Some difficulty was encountered in the field in distinguishing

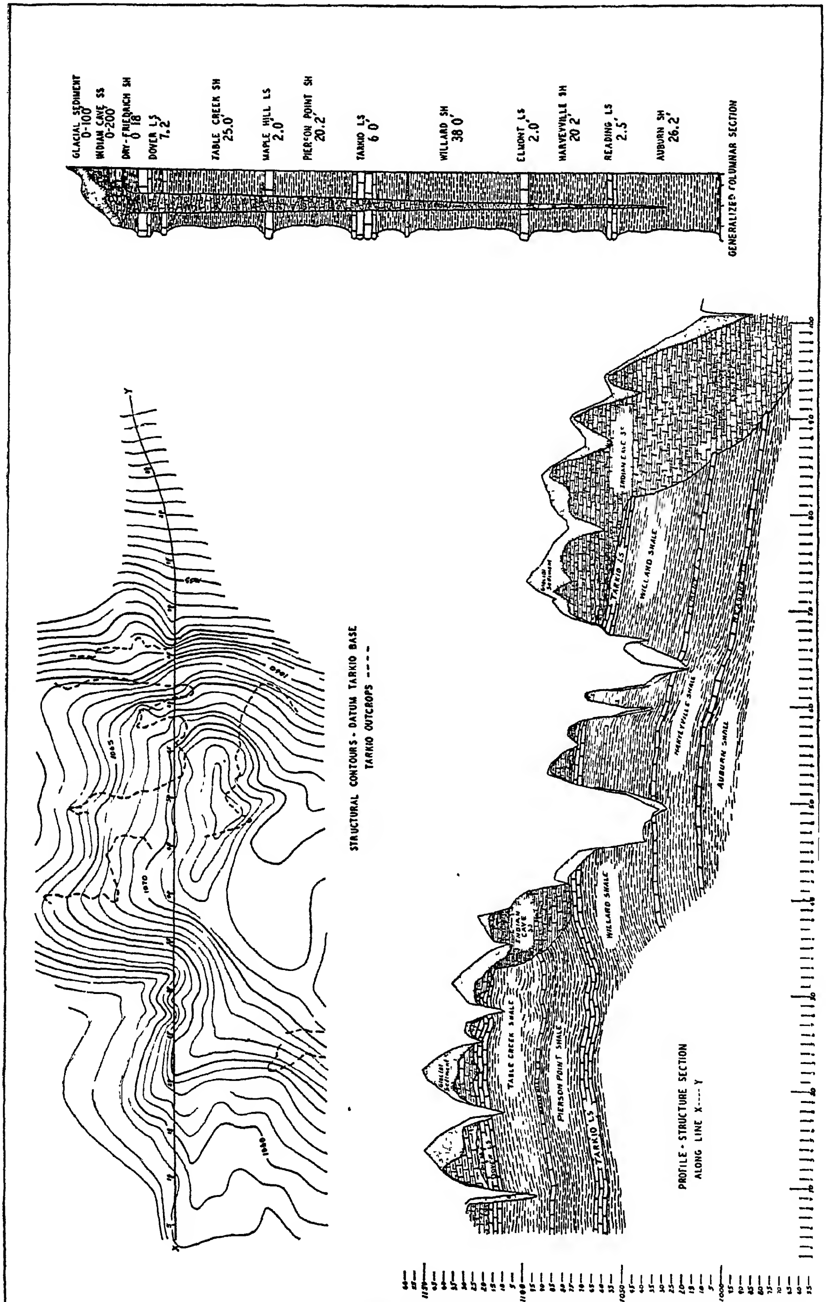

FIG. 1. Vertical scale in feet above sea level. Horizontal scale in 100 foot stations.

between the Indian Cave sandstone and certain of the well cemented and cross-bedded glacial sediments. This difficulty was overcome by means of petrographic methods. The heavy mineral suits were quite different and furnished an excellent basis for a quick, and accurate distinction between the two superficially similar deposits.

Conclusions

Within the area studied, the Indian Cave sandstone rests disconformably upon formations having a total stratigraphic thickness of about 250 feet. The maximum thickness for the formation was encountered at station 93 where the thickness is approximately 100 feet.

The Indian Cave sandstone disconformity extends downward a distance of 150 feet below the Dover limestone. The stratigraphic extent of this formation is now extended from the horizon of the Brownville limestone to the lower portion of the Auburn shale, a total distance of about 250 feet.

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Mellon Institute—Its Organization and Management

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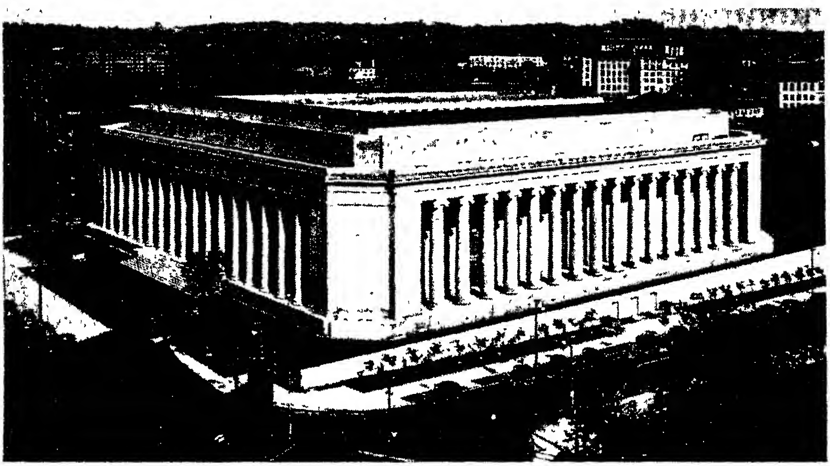
Research institutes are rapidly increasing in number, an increase due to a variety of reasons. The attention attracted by the spectacular results of war research, the desire to attract industry and to develop the use of raw materials in regions not previously industrialized, and increasing regional competition for industry are some of the contributing causes for this increase. In the Kansas region alone three such research institutes have been organized in the past several years. As a contribution to this trend in science, Dr. Weidlein has described the work of one of the pioneer industrial research institutes. In addition, this field is of special interest to Kansas because the Mellon Institute plan had its inception in Kansas and because the present director of Mellon Institute is a native Kansan. For further information about this Kansan, see page 374.—THE EDITOR.

Institutional research is becoming a very important part of our American life and the great stimulus that has been given to research during the war period has increased the number of institutions concerned. It will not be long before every section of the United States will have access to such research facilities. There is an increased demand for this type of service and especially by the smaller manufacturer who needs guidance in solving not only his immediate scientific problems but also in selecting and developing the proper personnel in order that he can eventually set up his own research laboratory. Dr. Robert Kennedy Duncan was a pioneer in establishing institutional research in America, as he inaugurated an industrial fellowship plan at the University of Kansas in January, 1907.

Dr. Duncan noted that the larger American companies had begun to employ expert scientific advice with huge resulting economies, but had kept their improved processes strictly to themselves, so that

the situation of the small manufacturer had grown more and more intolerable. Therefore, the question had come to him from every quarter of the English-speaking lands, and from many manufacturers of every size: "How can we utilize modern knowledge?"

Dr. Duncan gave as his answer a program which he had suggested and introduced at the University of Kansas. This procedure was to give the manufacturer the privilege of establishing a temporary fellowship in the University for the investigation of a particular problem, the solution of which would mutually and materially benefit both the manufacturer and the public. Such a grant from industry could be justified by the dictum that universities stand for the



Mellon Institute of Industrial Research, Pittsburgh, Pa.

uplift of man and that their absolute function is the increase and diffusion of useful knowledge.

He went on to point out that, while there were many men of scientific attainments already employed by industry, they were by the nearness of their connection unable to have the broadest vision. Really important problems could only be solved by rendering aid from outside—by qualified men attacking these problems with perfectly open minds and armed with a wide range of new facts apparently unrelated but potentially applicable. This conclusion was supported by the observation that during the 10 years preceding 1907 three fourths of the discoveries of industrial importance had emanated either from the universities or from men whose knowledge

was obtained therein. Thus by accepting such a fellowship the University provided the proper quarters for such a study, the scientific advice necessary for its solution, and, most of all, trained a scientific man for the service of industry. A fellowship contract of the kind proposed became a trust agreement, which the University could sponsor provided it was first convinced of the integrity of all concerned.

Thirty years later, and 23 years after the death of Dr. Duncan, the Honorable Andrew W. Mellon, speaking at the dedication of the present home of Mellon Institute, told how, in answer to a question posed by him about the soundness of a proposed process, he was given a copy of Dr. Duncan's *The Chemistry of Commerce.* Mr. Mellon said:

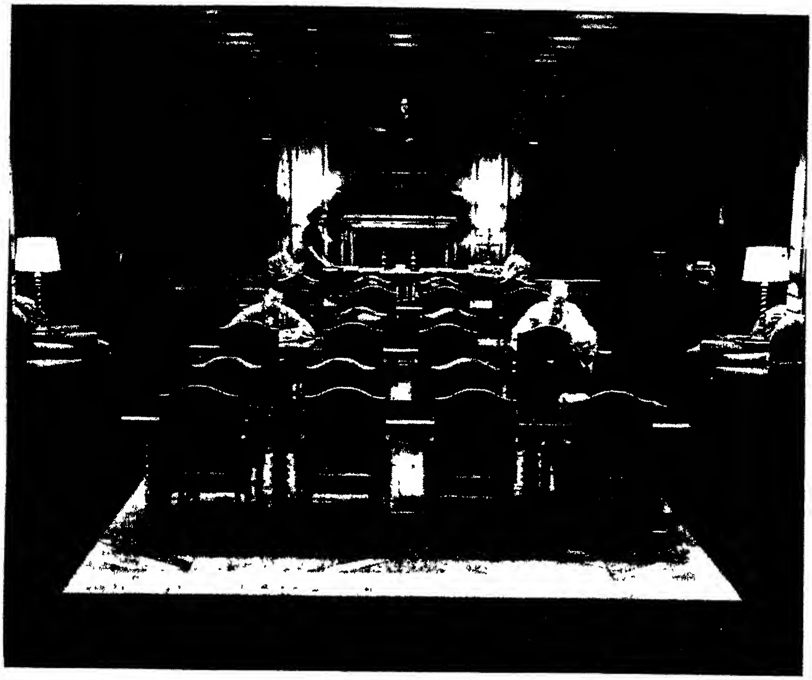
"I read the book with interest, but the part which particularly enlisted my attention was the last chapter in which Dr. Duncan described his plan for industrial fellowships.

"As a result of all my reading and observation, it seemed to me that improvement in the standard of living of the human race could come about in the future only by reason of new discoveries and inventions, just as, in the past, the steam engine and other inventions had been responsible for many improvements in the standard of living enjoyed by the average man today. It was these things, and not governmental or political action, that had increased production, lowered costs, raised wages, elevated the standard of living, and so had brought about a greater participation of the human race in these benefits.

"It seemed to me that an institution based on Dr. Duncan's ideas could help in this advance movement; and as my brother (Richard B. Mellon) was keenly interested in the project, we lost no time in persuading Dr. Duncan to come to Pittsburgh and organize for us here at our university this institute of research."

Dr. Duncan came to Pittsburgh in 1910 to establish the department of industrial research in the University of Pittsburgh. The idea was accepted with interest by industry, and in 1913 it was thought to have advanced far enough to deserve a permanent organization and a name. Accordingly, there was established by Andrew W. and Richard B. Mellon the Mellon Institute of Industrial Research, the name being given in memory of their father, Judge Thomas Mellon. A temporary headquarters was used for several years, an intended permanent home was occupied in 1915, and the present and, we now believe, a lasting building dedicated in 1937.

Mellon Institute has always been ready and willing to give assistance wherever possible in aiding the establishment of similar organizations. Research, like any successful undertaking, depends upon leadership, and institutional research requires close contact with the scientific personnel of the institution, and the support of the work by industrial donors. Of equal importance is the constant contact with the scientific professions. Research methods as well as administrative procedures constantly change and, therefore, while the same general principles are involved, it is well to study all types

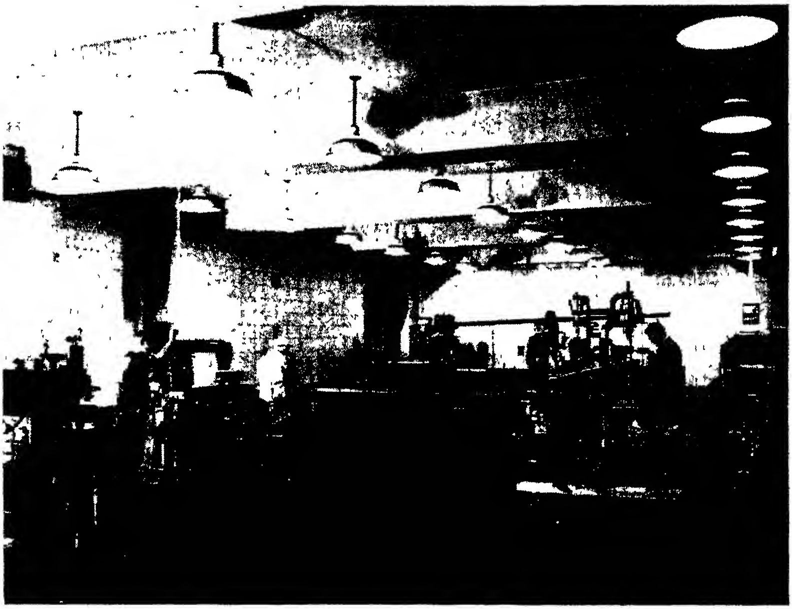


Reading Room in the Library of Mellon Institute.

of research organizations before establishing a new institution. Other research foundations have attained outstanding positions in their particular scientific fields; and when a problem in a specialized field is presented to one of the organizations not as well equipped to handle the research project in question, it is logical to refer the subject to another institution. This type of cooperation exists among non-profit organizations, as our success depends entirely upon results and how well we do the job. A successful research result will stimulate confidence throughout the industrial world and likewise will

bring additional support for fundamental research, which is the key to future progress. Therefore, in order to give our readers a better picture of the inner working of such an organization, I will describe Mellon Institute more in detail.

The general principle of the industrial fellowship as proposed by Dr. Duncan is still being followed. An agreement is made between the Institute and a donor, usually an industrial organization, which desires the investigation of a problem. The problem is studied



The Machine Shop of Mellon Institute—Here are grouped mechanical facilities for the use of all fellowships. Frequently a research fellow will prefer to perfect his own equipment for some special purpose in which precision is paramount, in which case he is free to use an adjoining shop.

by the establishment of a fellowship, the donor paying the Institute a foundation sum covering the actual cost of the research program. The exclusive purpose of the fellowship is set forth in the agreement, and it is understood that the fellow is to devote his time to the pursuit of that investigation. Originally the fellow was a graduate student in the University; now the fellowship is postdoctoral in nature although the doors of the graduate school of the University are open gratis to any fellowship researchist. The salary of the fellow is derived from the foundation sum paid under the agreement. Originally the fellow's stipend was that customary for a graduate student; now

it is the salary of a competent research worker. At first, all the fellow's tuitional fees were to be paid by him from his stipend. Then the fellow participated in the profits of any invention to the extent of 10 per cent of the net proceeds. His status now is that of a salaried employee, but at the discretion of the donor of the fellowship he may receive such bonuses as are customary in the donor organization.

Any discoveries made by the fellow become the exclusive property of the fellowship donor, and the fellow and the institute are bound to assign to the donor all rights in every discovery. Neither the University nor the Institute has a financial interest in nor can they derive a penny of profit from the work of any fellow. The fellow and his advisers have always been bound to hold in confidence any information received from the donor or developed during the research. This regulation has been applied to the extent that, although the fellowship agreement has in all cases permitted publication after a lapse of time to protect the donor's interest, no publication has ever been made unless actually released by the donor.

There are some phases of the operation of the Institute that justify a fuller discussion because they contribute to the proved success of its research procedure. The purpose of the investigation is clearly set forth in the fellowship agreement and, if necessary, is amplified and clarified by an exchange of letters. In order to guarantee the rights of a donor in fellowship findings, the purpose of each fellowship is regarded as an exclusive reservation to that donor. Only in the event that a field is released by a donor is another fellowship accepted in that particular field. Modern industry covers broad domains, and, while a number of fellowships may be existent therein, the portions allotted to the respective fellowship and donors are definitely limited so that at no time is there competition or overlapping in the researches. This practice is carried out to the extent that, should any fellow make a discovery germane to the fellowship purpose of another donor, the latter is given an opportunity to acquire an interest in the new development.

Every fellowship operates under a specific agreement between the company or individual (the donor) sustaining the fellowship and the Institute. This contract is for one year, and a simple agreement between the Institute and the fellow runs for the same period. The agreement fixes the dates for the beginning and ending of the fellowship year; stipulates the cost of the fellowship (the foundation sum); and states briefly the exact purpose of the program, but provides that the purpose and life of the fellowship may be extended

by mutual agreement. It is stipulated that the Institute shall retain 20 per cent of the foundation sum to cover general overhead charges, and shall use the remainder for investigators' salaries and research expense.

The cost, or foundation sum, of an industrial fellowship is determined by the salaries of the incumbent and needed assistants, the actual cost of research materials including specialized equipment required, and the amount of traveling necessary for the fellow in the course of his studies. Since fellows of all degrees of competence and

Molecular distillation of lubricating oil in petroleum research at Mellon Institute.

experience are employed by the Institute, salaries will be found comparable to those of any other large research organization. For purposes of illustration, a foundation sum of $7,500, after deduction of the 20 per cent overhead charge, amounting to $1,500, would ordinarily provide a salary budget of $4,000 to $4,500, and an expense or apparatus budget of $2,000 to $1,500.

There are numerous overhead services required in operating a research laboratory. Nearly every investigation, regardless of the number of persons employed, will require all these services in time. There must be a reserve of equipment, both general and special,

that can be drawn upon at short notice, which requires a well-stocked storeroom and apparatus cabinets. Although the average investigator usually needs few works of reference, he must be able, on occassion, to look up quickly unusual facts in a comprehensive library. He cannot afford to employ a mechanician and a glassblower and maintain an instrument shop for the few calls he will make upon them, but neither can he well afford the loss of time involved in hunting out a commercial shop to serve his occasional wants. His laboratory must be cleaned daily, he must have office help available, and there must be messengers at his call.

Except for the fairly large staff of the research laboratory, some of these services, but not all, may be furnished by the operating divisions of a business that has a laboratory in its plant. Such sharing, which cannot include glass-blower, library, or chemical storeroom, is often only for such time as the factory has no need for the space used. A small laboratory outside of the plant pays heavily for such facilities, or does without. Our fellows, on the other hand, can share a library of over 20,000 volumes, a repair and construction department not only well outfitted with machines, but well staffed with mechanicians, steam fitters, plumbers, electricians, other artisans, and laborers. There are also available highly skilled glassblowers, instrument repairmen, a photographer, and draftsmen. In addition, for 18 years an analytical department has taken from the fellows' shoulders the burden of routine as well as many specialized analyses. The Institute can thus furnish at a very low cost per fellow a very complete line of service to all the fellowships.

The choice of fellows and assistants is placed in the hands of the Institute, although appointees must be acceptable to the donor. The fellow is to devote his full time to the pursuit of the investigation, and is to receive the benefit of both the advice and direction of the executive staff of the Institute and the expert knowledge of the donor. Pilot-plant operations may be, and usually are, carried on at the Institute, are jointly agreed upon, and are covered by a separate budget. The fellow is required to submit monthly progress reports to the donor through the executive staff and also to present a comprehensive monograph covering the work of the fellowship at the termination of the research program.

It is provided that all reports of the fellowships are retained in the private files of the Institute and made known only to the donor unless specifically released by the latter. When authorized by the donor, the fellow is to make application for patent protection on any

of his developments, is to assist in the prosecution of the applications, to assign them to the donor or trustee as instructed, and, when necessary, to assist in the defense of the granted patent. It is also provided that if the donor does not wish to seek patent protection the fellow may not take such action, except of course with the donor's permission. It is further provided that there shall be no publication of fellowship findings, by the fellow or the Institute, without the donor's consent, until such time has elapsed that the donor shall have had opportunity to protect himself in every way.

Industrial fellows may be appointed by the Institute from the open employment market or, at times, may be drawn from the donor organizations. As stated above, while the fellow must be mutually acceptable to the Institute and the donor, final approval rests with the Institute, as it is the actual employer of all personnel. When, at the termination of a fellowship program, the fellow does not enter the employ of his donor, an opportunity is usually afforded for him to become associated with another fellowship project.

The Institute has a notable record of publications. Industry rapidly is learning that more is to be gained by broadening the field of useful knowledge than by drawing the veil of secrecy over research developments. In the 34 years that ended December 31, 1944, members contributed to the literature 21 books, 185 bulletins and 2,076 journal articles, in addition to the voluminous work recorded in the various compendia of standards in the revision of which the Institute participates. In the same period, members have been issued 947 United States patents and 895 foreign patents.

Finally, it is provided that no publicity of any sort, descriptive circulars, newspaper or magazine advertising matter in which the name of the Institute is mentioned shall be utilized by the donor unless the relevant copy has been expressly approved and released by the Institute. It is not permitted in such copy to use a picture of the Institute nor to reproduce a letterhead or report form of the Institute.

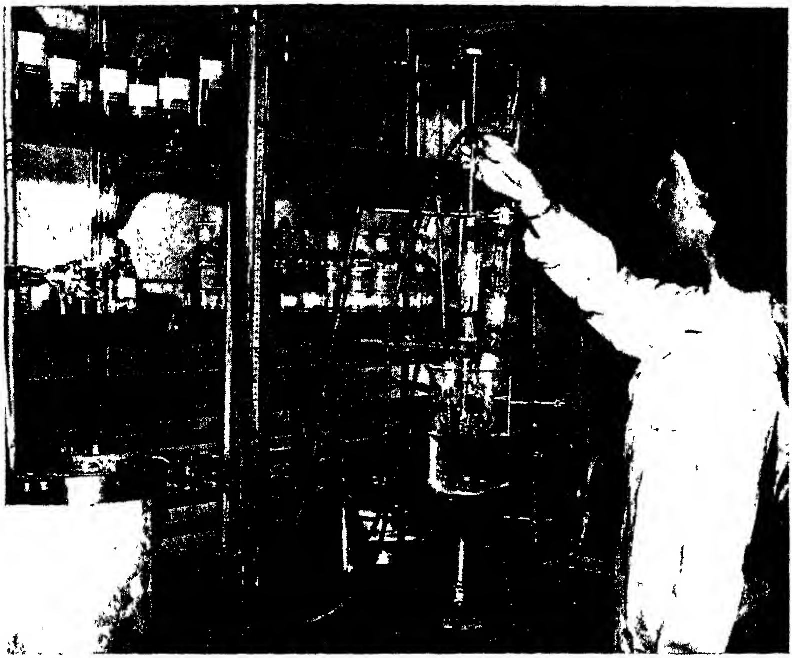
The size of the corporation desirous of establishing an industrial fellowship has never been a matter of concern to the Institute. Provided the proposed study is in an open field, the pertinent considerations are:

(1) The subject must be one that may be approached by application of scientific research methods. There is no desire merely to collect data, for example, for the use of a public relations bureau.

Neither should it be the sort of work that belongs properly to a testing laboratory, whose speciality is commercial analytical chemistry.

(2) As it is anticipated that the fellow shall devote his full energy to its study, it is desirable that the research project be one which, provided regular progress is made, will continue for several years.

(3) The Institute executive staff must be convinced that the donor organization will lend its active support to the fellowship program, will make available its own expert knowledge and experience,



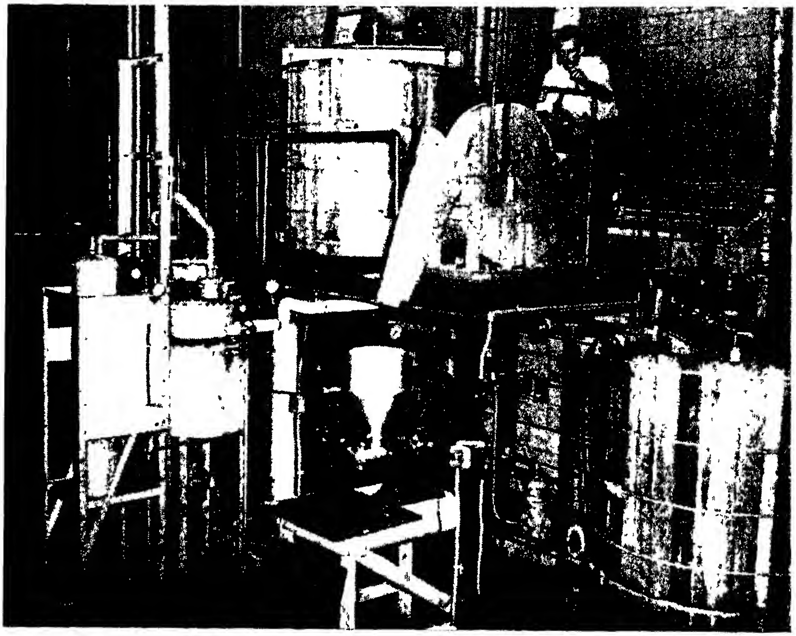
A step in the synthesis of a potential antimalarial in the department of research in pure chemistry at Mellon Institute.

and will afford the cooperation of its own research, development, or manufacturing department wherever indicated. A fellowship is a partnership venture, the principal difference between it and other partnerships being that, if successful, the Institute's only share will be, at most, some of the credit for solving the problem, the financial return going entirely to the sponsor, the donor, in every instance.

(4) The Institute has always looked with favor upon major research undertakings that involve public welfare or public or industrial health.

It has been particularly proud of its smoke and dust control investigations, of the Industrial Hygiene Foundation, and of its work in chemical hygiene, on hatters' fur, on the disposal of wastes from steel mill and by-product coking operations, and of the numerous other instances in which it has given help in the abatement of important nuisances.

The Institute's interest in researches affecting professional and public welfare is also instanced by its department of research in pure chemistry. In this branch, sponsored by the Institute, have been conducted important studies in public health, such as chemo-



Pilot-scale production of a new plastic.

therapeutic investigations of pneumonia and malaria, researches on the etiology and pathology of dental caries, and researches on the standardization of drugs and medical preparations in collaboration with the committee of revision of the United States Pharmacopoeia.

The greatest contribution has been our services to the Government in World War I and World War II. The Institute gave its complete facilities in both wars to Government service directly or indirectly through the donors.

The Institute from the time of its inception has served simul-

taneously both large and small donors. Some of them have research departments of their own, perhaps most of them are making attempts to engage in research within their organizations, nevertheless a goodly number have neither research facilities nor research staffs. The contact with a donor is not necessarily through the research department where such a department exists. We might as well admit that there are a few instances, very few we are happy to say, where the donor's research department has been out of sympathy with the purposes or even the existence of the fellowships concerned. But generally these antagonistic departments can be won over by tact and accomplishments.

An industrial fellowship may remain the sole research division of a donor organization. In other cases, the fellowship expands and splits, a part going directly to the donor to become his research division, and the remainder staying in the Institute to be, as it were, the listening post. There are some large donors that use parts of their fellowships as permanent research groups and have attached thereto as nuclei younger groups of revolving personnel who are really attending a training school.

Where a large family of researchers are working in the same surroundings but in noncompetitive fashion, no man's advancement depends upon getting a coworker out of the way. This fact has generated an *esprit de corps* that permits and encourages freedom of discussion of bothersome questions. At the present time 80 fellowships are in operation, which means 80 different large applications of chemistry and closely related sciences. Expressed in another way, there are specialists in the family in nearly every conceivable phase of chemistry, so that an investigator who finds himself confronted with a question outside his field of training is quite certain that some member of the family will think out loud with him for a few minutes in an effort to clear away the mental fog. Not every fellow can grasp this attitude at once, but it has become so much a part of the Institute atmosphere that very few persons of competence do not fit themselves into it in a relatively short time.

A good part of whatever success the Institute has had is the result of its encouragement of the fellows to become of value in their donors' businesses. It is quite obvious that the executive staff, because of its manifold relationships, can only be expert in research methods, trying to apply whatever hard common sense can come from a knowledge of practical general science and laboratory management. It is the duty of the staff to keep every fellow hewing to the line and,

out of its own broad experience, to aid the fellow in the interpretation of his findings to the donor. The fellow must be able to think of his donor's product as though he were beside the machine or to follow it in his mind through the mechanical operations in which it is used. In this connection, the most successful fellow is the one who does not say "Smith's product," but "our product."

Many wish to know how it is that an industrial fellowship can succeed without constant, literally daily, plant contact. A great many of us do realize that constant access to a manufacturing plant is not a particular aid to research. The big problem in any plant is production, which has become the fetish of the superintendent, who cannot tolerate any interruption for a trial run. And the securing of a trial run requires the most diplomatic relations between the investigator and plant workers, because the latter picture any such experimental runs as reacting unfavorably upon their pay checks. A production line is not the place for the first trial of a new process, any more than we would attempt an entirely new reaction in a 10-liter flask. In the majority of cases, even a pilot plant is too large for a beginning. The experience of the Institute in building and operating small pilot plants as adjuncts to research laboratories is such as to confirm the managemental axiom that research operations, speaking mechanically, should not go to the parent plant until time to enter the production line.

What is needed more than anything else is a place where the investigator can think of his problem undistracted by what is going on in the plant around him. He must be able to view it many times with an utterly detached mind, as one looks at a bug under a microscope; to view its outlines from different angles and from different viewpoints, seeing it perhaps as some new object and in that way sensing its relationship to other, perhaps entirely different, operations. He must be able to continue until, having recognized a succession of analogies, he reaches the point where he can supply an experimentally proved fact, then perhaps by a bold jump translate this finding into the solution of his own problem.

There is still another angle. One who is in daily contact with an operation will, if he is not careful, find the wheels of his mind synchronizing with those of the machines around him. He will, if not particularly immune, come eventually to believe that things must be done in a certain way, deadening his imaginative faculties. Furthermore, in time of stress, it is so easy to order every technical man on the ground to devote his attention to what the management

considers an emergency, thus interrupting a train of thought which, after numerous switchings, has just gotten out onto the main line with a green light ahead.

The industrial fellowship system was organized in the spirit of a university's participation in the affairs of the people. Mellon Institute, affiliated with a great university, has continued in that tradition. Any Institute research worker is welcomed as a graduate student within the doors of the University, while many senior institute members make their contributions as university lecturers. The Institute strives to serve as a clearinghouse for scientific information, not for its fellows and donors alone, but for all who inquire. Its library is open to all comers during daily hours. Not only is the Institute a research center, it also functions as a research training school. Some of the fellowship members have spent their professional lives within its walls, others have gone to high places in industry and education. The security of its position is evidenced by the fact that, of the fellowships in operation at the beginning of the current year, 7 have been active for more than a quarter century, 1 for over 20 years, 6 at least 15 years, and 16 have been at work a decade.

This is a brief picture of our endeavor to realize the conviction of the founders that only through the application of modern science to industry can there come into the world an era of gracious living.

The achievements of "pure" science in one generation constitute the formulae of the "applied" science of the next, and outside altogether of material application they have their abstract justification. But in our day, the preferred work of the world is the doing of real things, i.e., things having significance to human needs, whether material or concerning thought or conduct. Even today the manufacturers of this country have so far awakened to the need of efficiency that the universities can barely supply the demands for adequately trained men and yet the progress of this industrial transformation has only just begun. In no field of human effort do there exist such opportunities for genuine achievements as shall exist in the next twenty years in Industrial Chemistry.—Dr. Robert Kennedy Duncan, *The Chemistry of Commerce,* 1907.

The Editor's Page

Transactions
of the
Kansas Academy of Science

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VOL. 48, NO. 4 MARCH, 1946

ROBERT TAFT, *Editor*

Samuel Johnson once remarked that "the worst man does more good than evil," and a modern essayist of national repute, C. Hartley Grattan, recently wrote "Good men have done an appalling amount of harm in the course of human history." From a scientific standpoint, both judgments are open to suspicion as neither writer produced the statistical data upon which each based his judgment. Possibly, however, the conclusions of these eminent men are like the second law of thermodynamics, so obvious as to require no proof.*

Whatever doubt the scientist may have of the validity of the maxims of Mr. Johnson and of Mr. Grattan, it is safe to say that few would disagree that past human experience has shown that not all one man does is wholly good or is wholly bad. To cite a case that should be of interest to Kansans, let us recall the behavior of Samuel C. Pomeroy. Pomeroy and James J. Lane—another "case" we could discuss if time were available—were the first United States Senators from Kansas when statehood was achieved in 1861.

Pomeroy has been accused of hypocrisy, of forgery, of thievery, and of bribery. Although absolute proof on all these points is lacking, so overwhelming was and is the evidence against him that there seems to be little doubt that Pomeroy's record was very considerably on the debit, rather than the credit, side of the Great Ledger. In fact, so extensive was the evidence of guilt against him that Pomeroy left Kansas in 1873 under a dark cloud, a very dark cloud indeed, and never returned.

It is possible, however, even for the amateur historian to disinter considerable good from the bones of our first senator. In the first place he was a powerful and eloquent orator in the days when oratory was power, and his eloquence was used in many good causes. One of the

*One of the briefest statements of the second law repeats the common maxim that "Water seeks its own level". To see a stream suddenly reverse its direction and flow *up* hill would doubtless astound even the simplest of mortals.

great speeches of his career was made in support of the Homestead Act of 1862 (an act of great importance in the development of Kansas). This speech was in fact the longest and most eloquent speech made in either the United States Senate or in the House of Representatives in support of this bill.*

Even today, reading the peroration in the small, cold type of the *Congressional Globe* will cause the spine to tingle despite its obvious flag waving and eagle screaming style. At least, the editor believes it will to most people and if the reader wishes to try its effect for himself, he should turn to page 377.

In addition, to the Homestead bill, Pomeroy actively supported the Morrill Land Grant Act (also enacted in 1862) which has had far-reaching effects in our system of higher education as witness our own great Kansas State College at Manhattan.

To reveal still another aspect of this strange man, my colleague, Professor James C. Malin, tells me that he has read a letter written by Pomeroy to one of his own young friends; a letter graciously, solicitously and amusingly written. A small incident, to be sure, but one revealing an entirely different facet of Pomeroy's life. In fact, his personal magnetism seems to have been so compelling that his many friends absolutely refused to believe the charges of wrong-doing brought against him when evidence of his guilt was well-nigh overwhelming. Possibly a careful study of his career would bring still other aspects of this man to life—a study that awaits some future biographer, who, we may hope, will be able to explain the general contrariness and cussedness of mortals.

* * *

Edward Ray Weidlein, chemical engineer and author of our feature article, was born on July 14, 1887, at Augusta, Kansas. We mention these facts for several reasons. As a scientific pub-

DR. E. R. WEIDLEIN

lication, we should be precise and accurate in our statement of fact and we believe these facts are accurate and precise because they are published in *Who's Who in America,* whose editor in turn

*This speech in its entirety is published in the *Congressional Globe* for May 7, 1862. The listening senators, habituated to oratory in all its forms, were so impressed with the speech that they waived by common consent a special order of the day that was reached when Pomeroy was nearly half-way through his speech—an unusual procedure.

presumably obtained them from Dr. Weidlein himself. In the next place, specifying his birth date may prove of some advantage to the author, for some readers may be so grateful for his article in this issue that they will wish to remember him on his birthday. He certainly deserves some reward in return for his kindness and willingness in preparing the article for us. We hereby take this opportunity to express publicly our appreciation to him. In the last place the information in our opening sentence is evidence that he is a native Kansan, a fact of which the state has reason to be proud. In fact, he was a resident of Kansas for some years after 1887, securing his bachelor's degree from the University of Kansas in 1909 and his master's degree the following year. He was one of the earliest industrial fellows under Dr. Robert Kennedy Duncan at the University of Kansas. When Dr. Duncan moved on to the University of Pittsburgh, Dr. Weidlein went with him and was associated with the early beginnings of Mellon Institute. Weidlein's most extensive experimental work has dealt with the metallurgy of copper, in which work he was engaged for some years. He became assistant director of Mellon Institute in 1916 and since 1921 has been its director. He is an active member of many national organizations and among his numerous honors has been the presidency of the American Chemical Society, probably the largest professional organization in existence. He has been a member of the Academy since his student days at the University and several years ago was kind enough to write: "The Kansas Academy of Science has had a wonderful record during the years and has had as its members some of the outstanding scientists of the world. Its influence has been fine in encouraging the development of science. During my early scientific career, I was greatly stimulated by my contacts with the Academy."

Dr. Weidlein, in addition to numerous contributions to scientific periodical literature, is the co-author of two books: *Science in Action* and *Glances at Industrial Research.* During World War I, he served as chemical expert on the War Industries Board, and in World War II was chief of the chemical branch of the War Production Board and technical adviser to the Quartermaster Corps, U.S.A.

* * *

Attention of our readers is directed to the review of Kansas weather by Mr. S. D. Flora, meteorologist for Kansas in the United States Weather Bureau. We hope to make such reviews an annual feature of the *Transactions* hereafter. Although the data published could be collected in more detail by the scholar from the monthly *Climatological Data, Kansas Section,* published by the U.S.D.C., inclusion in the *Transactions* will make these reviews accessible to many readers. Weather, we scarcely need repeat, is of so universal value and interest that the editor believes the publication of these reviews will prove most welcome to Academy members. In addition to their intrinsic value, these re-

views should help to settle many an argument. For some of our lower-browed members they might even prove a source of income. If, for instance, one read up thoroughly, from Mr. Flora's article, the weather conditions of February, 1945, and then selected an unsuspecting victim for argument of last February's weather compared to this February's weather, the argument might net a little cold cash to the informed reader. We are not recommending this procedure, you understand, but just exploring the many possibilities that such annual publication may eventually produce.

* * *

Dr. Zabel's paper "The Contribution of Kansas to American Men of Science, 7th Edition" on page 409 of this issue is one of real interest in many ways. The unusually high position of Kansas, a state of comparatively small population (about 1,800,000 at the 1940 census), shown in Figure I of the Zabel article is indeed remarkable. In addition, it may be noted that four mid-western states closely allied geographically (Kansas, Missouri, Iowa, and Nebraska) have a total of 3700 native born scientists; the total combined population of these four states is 9,500,000. New York, on the other hand, with a state population of 13,500,000 has produced only 3200 individuals listed in the 7th edition of *American Men of Science.* A serious study of such differences—and many others indicated by the Zabel article—should, in the editor's opinion, be well worth while. An exhaustive study of these differences might well be of benefit in encouraging or discouraging future growth and expansion in the scientific profession.

We should also point out that Dr. Zabel is a native of Minnesota, and has never been associated with a Kansas school. He received his training as an anatomist and obtained his doctorate from the University of Chicago; after several years' experience as a university instructor he became a representative of a scientific supply house and is now associated with the Clay-Adams Company of New York City. His territory covers a considerable portion of the middle west and his name and face are familiar to many teachers of science throughout this area. We recommend that all readers of the *Transactions* give Dr. Zabel's article their close consideration.

A Kansas Orator Speaks on the Homestead Bill

Sir, standing in this high point of the nation's Capitol, having been occupied almost exclusively with matters pertaining to the war, I think we should not be insensible to the requirements of peace! We are, I trust, soon to have our brave soldiers returned to peaceful avocations. When no longer needed in the service, they will return to their anxious families. But a life in the camp, and distant marching and counter-marching, has so extended their vision and unsettled their plans and habits, that the returned soldier, then a citizen, will be among the first to move to the new and unsettled regions of the West. And, sir, we cannot do better for this citizen than to give him a homestead upon the soil he may have saved, and protect him by the Government he has defended; and settlements founded by these men, who have had the discipline and devotion of soldiers, will be safe depositories of the institutions of free government. The savage on the one side, or the traitor on the other, will never invade his quarters. So then I say that while we are preparing for the exigencies of war, let us not forget the condition of peace.

. . . .

This bill, enacted into law, shall give civilization and life throughout the silent gorges and gentle sleeping valleys, far away into the deep recesses of the continent. Where it leads the way, there shall go in triumph the American Standard, the old flag of the Union. And when once thus planted, it shall never again be trailed in the dust. The proudest bird of the mountain is upon the American ensign, and not one feather shall fall from her plumage here. She is American in design, and an emblem of wildness and freedom. I say, again, she has not perched herself upon American standards to die here. Our great Western valleys were never scooped out for her burial place. Nor were the everlasting, untrodden mountains piled for her monument. Niagara shall not pour her endless waters for her requiem; nor shall our ten thousand rivers weep to the ocean in eternal tears. No, sir; no. Unnumbered voices shall come up from the river, plain and mountain, echoing the songs of our triumphant deliverance, while lights from a thousand hill-tops will betoken the rising of the sun of freedom, that shall grow brighter and brighter until a perfect day.—The Honorable S. C. Pomeroy, Senator from Kansas before the United States Senate, May 5, 1862 (See further, page 373).

Spring cannot be far away for in a few weeks the wild plum thickets will fill the air with their fragrance on prairie, roadside and river bank. The white flowers of Prunus americana usually begin blossoming in the first two weeks of April. The bushes, growing from 8 to 15 feet in height, bear their ripened red or yellowish fruit in August, are pleasant to the taste when fully ripe, and thus played a part in the economy of our early settlers. This excellent photograph of a Kansas plum thicket in bloom was taken by Professor W. C. Stevens, veteran botanist of the University of Kansas. Professor Stevens' book "Introduction to Kansas Wild Flowers" will probably be published during the current year. We are indebted to Professor Stevens for his kind permission to reproduce this photograph and the one on page 408.

Scientific News and Notes of Academy Interest

Items for this column are solicited from all Academy members. For inclusion in any given issue they should be in the editor's hands at least three weeks before our publication dates, namely the fifteenth of March, June, September and December.

The 78th annual meeting of the Academy will be held at the Kansas State Teachers College, Emporia, on April 11-13. All old members of the Academy should be on hand to welcome our many new members. Official notification of the meeting will doubtless have reached all members by the time this issue of the *Transactions* is in the hands of our readers. The principal address of the meeting will be given by Mr. E. Finley Carter, vice president, Sylvania Electric Products Company of New York. The subject of Mr. Carter's address, to be given at 11:00 a.m. Friday, April 12th, will be "The Scientist's Increasing Social Responsibility."

The local committees at Emporia are headed by Professors S. W. Cram and H. E. Schrammel who urge that all members expecting to be present will fill out the form enclosed with the official announcement and return it at the earliest convenient moment.

Did you secure a new Academy member during the past year? Such was our goal for every member decided upon at the last annual meeting of the Academy. A few of our members have done far more than their share and have secured 50 to 100 new members. There is still time to obtain a new member before our Emporia meeting if you have not already secured one. If each person who has not yet secured a member will do so before April 11th, our membership will be well past 1100.

One indignant charter member of the Illinois State Academy of Science writes that Illinois was omitted from the list of state academies of science given in our last issue (page 280) in connection with a review of Professor Bates' book *Scientific Societies in the United States.* Our correspondent concludes "How could it [Illinois] be skipped in your list?" Well, the editor has no respectable or satisfactory answer to make. The editor and Professor Bates both owe the Illinois State Academy of Science an apology for the omission.

The Illinois Academy is one of our largest and most active state academies and was founded in 1908, according to our indignant correspondent and confirmed by the report of *The Academy Conference,* A.A.A.S., Sept. 11, 1944, p. 16. To all interested, the omitted academy should be inserted in the list given in the last issue of the *Transactions.*

Dr. A. B. Cardwell, head of the physics department, Kansas

State College, returned, on March 15 after a leave of nearly two years, to his duties at Manhattan. Dr. Cardwell, associate editor of these *Transactions,* has been serving as research physicist for the Clinton Engineering Works, Oakridge, Tennessee, on the now famous atomic bomb project. During Dr. Cardwell's absence from the College, Dr. Stuart Whitcomb has been acting head of the department of physics.

The many friends of Dr. H. H. Hall, past president of the Academy and professor of biology at Kansas State Teachers College, Pittsburg, will deeply regret to learn of his death on January 2, 1946. Long an active member of the Academy, his loss will be keenly felt. A more extended account of Dr. Hall's life will be published in volume 49 of these *Transactions.*

We also regret to report the death of Dr. C. E. McClung, an honorary member of the Kansas Academy since 1903, on January 17, 1946, at his home in Swarthmore, Pennsylvania. At the time of his death, Dr. McClung was director emeritus of the zoological laboratories, University of Pennsylvania. His obituary will also appear in volume 49 of these *Transactions.*

Mr. S. D. Flora, meteorologist for Kansas, U. S. Weather Bureau, has long had in mind the preparation of an extensive monograph on Kansas weather, somewhat on the plan of the excellent treatise *Climate of Indiana,* by Dr. S. S. Visher, professor of geography at Indiana University, published in 1944 by the University of Indiana Press.

The size of the clerical force necessary to examine the vast store of data available in the weather bureau office at Topeka, and to undertake its compilation and analysis has been one of the chief obstacles in the preparation of such a Kansas monograph.

A start, however, has been made. Last December Mr. W. A. Mattice, formerly Chief of the Climate and Crop Weather Division of the Weather Bureau, Washington, D. C., was assigned to Topeka to free Mr. Flora of much of his routine work and to collaborate with him in the selection and arrangement of matter to be used. This work is already under way. Additional aid, of course, must be secured before the monograph can be completed.

Another serious problem that must be solved before Mr. Flora's project can be completed is that of securing funds for publishing this study of Kansas weather. Mr. Flora estimates that between four and five thousand dollars will be necessary for publication. Possibly funds for this purpose might be secured by solicitation from public-minded citizens of the state or by contribution from various research funds available in the state's public institutions.

Mrs. John Schmidt, a graduate of York College, Nebraska, has been appointed instructor in botany at Tabor College, Hillsboro. Mrs. Schmidt who received her master's degree from Kansas State Teachers College, Pittsburg, formerly taught in Parsons Junior High School and Buhler High School.

The fifth in our series of brief reviews of research centers in the Kansas region deals with a nationally known institution, The Menninger Foundation of Topeka, Kansas, a non-profit foundation for psychiatric research and education, which was incorporated September, 1941. It operated for several years in cooperation with the Menninger Clinic and Sanitarium, but at the annual meeting of the Foundation, December 4, 1945, the trustees of the Foundation voted to accept the offer of the owners of the Sanitarium and Clinic to donate all their property and holdings to the Foundation, and to merge these assets with the Foundation. The trustees of the Southard School, a non-profit psychiatric school for children, will offer, at the end of its fiscal year (June 30, 1946) to merge with the Menninger Foundation so that the Foundation finally will embrace all the facilities for treatment, research and education of the combined Menninger organizations.

The establishment of the Foundation was the logical outgrowth of the 20 years of psychiatric treatment, education and research which have been carried on by the Menninger Clinic, the Hospital and the Southard School, all of which were founded by Dr. C. F. Menninger, a life member of the Academy, and his two sons, Dr. Karl and Brig. Gen. W. C. Menninger, and by their associate, Mr. John R. Stone, all of Topeka.

Buildings and grounds of the Menninger Foundation, Topeka.

The educational work of the Foundation consists of a training school in psychiatry for graduate physicians whose clinical work is assigned in rotation at the Menninger Psychiatric Hospital, the Veterans Administration Hospital in Topeka and

the Southard School for children, and the Municipal Clinic. The training school program will require three years for its completion. The school was organized to meet the national need for large-scale training of psychiatrists and was greatly facilitated by the cooperation of the Veterans Administration.

A graduate training school in psychiatry for nurses is also maintained and psychiatric field work for social workers and occupational therapists is conducted in association with university schools. Training courses for psychologists are conducted by the department of psychology of the Menninger Clinic. Some extra-mural educational work in psychiatry is carried on through the *Bulletin of the Menninger Clinic,* a psychiatric journal published by the Foundation, and through lectures and institutes.

The research department has recently prepared a report of a three-year research in the validation of diagnostic psychological tests by David Rapaport, Merton Gill and Roy Schafer, which has just been published by the Yearbook Publishing Co., in 2 volumes. A manual entitled *Diagnostic Psychological Testing* was also prepared for the Macy Foundation who published it and distributed 10,000 copies to psychologists and psychiatrists of the American and Allied armed forces.

An investigation of the applications of hypnosis in modern psychiatry by Drs. Merton Gill and Margaret Brenman has been in progress for almost two years and several interim reports have been published in various journals. A review of the literature pertaining to hypnotherapy has also been published and distributed to the psychologists and psychiatrists of the American and Allied armed forces. About a dozen other research projects are being carried on at the present time and several more are in preparation. The Foundation has its own buildings, comprising laboratories, class rooms, conference room and offices, located at 3612 West Sixth Avenue, Topeka.

In our last issue, we made brief report of the war-time activities of the Sunflower Ordnance Works near Lawrence. Further data is now available on the size of the scientific staff at Sunflower during peak production and which we here add to make our report and record more complete.

The Hercules Powder Company employed at Sunflower 30 chemists, 182 laboratory technicians, 20 ballistic supervisors, 173 ballistic technicians, 10 chemical engineers. In addition, the U. S. Government (ordnance department) employed 5 chemists, 20 laboratory technicians, 1 ballistic engineer, 3 ballistic technicians, 3 chemical engineers for process inspection.

Mr. David M. Gates, for the past several years engaged on war research with the proximity fuse, has returned to the University of Michigan to continue work on his doctorate in physics.

Loren W. Mentzer, who recently returned from two years of overseas service as a laboratory technician with the 19th

General Hospital, U. S. A., began work as instructor in biology, Kansas State Teachers College, Emporia, with the beginning of the present semester.

Dr. Cora M. Downs, professor of bacteriology at the University of Kansas, it has now been revealed, was section head of one of the groups engaged in the study of the defensive and offensive aspects of bacteriological warfare, one of the top secret research projects during the war. Dr. Downs' section was located at Camp Detrick at Frederick, Maryland. Her work began in August, 1943 and ended in October, 1945, although for part of this period she commuted between the University campus and Camp Detrick. Many other Kansans were also associated with various aspects of the project. Dr. Downs reports "that knowledge was gained about bacteria and how to control them which not only put us ahead of the Axis partners but which has advanced the treatment and prevention of infectious disease by the equivalent of fifty years' work."

Major Albert W. Grundmann received his discharge from the U. S. Army late last fall after his return from the Philippines. He reports that he was fortunate in securing a position with the University of Utah, Salt Lake City, in the department of biology as soon as he was discharged. Mr. Grundmann hopes eventually to undertake research on equine encephalomyelitis.

Dr. Robert Bugbee, associate professor of zoology of Fort Hays State College, who is now on leave, is teaching temporarily in the zoology department of the University of Rochester, Rochester, New York.

Dr. E. H. Sellards, director of the Texas Memorial Museum, University of Texas, has recently announced the discovery of prehistoric buffalo remains and associated human tools. At the request of the editor, Dr. Sellards has kindly prepared the following brief review of this important discovery:

"The first discovery in America of a human tool associated with the skeletons of fossil bison was made a half century ago in Kansas, by Handel T. Martin and T. R. Overton of the University of Kansas, and was announced by Professor S. W. Williston in the publications of the Kansas Geological Survey, volume 2, and in the *Transactions of the Kansas Academy of Science,* volume 15. The intervening half century has afforded several additional similar associations, particularly in Nebraska, New Mexico, and Texas. A discovery made in Texas in 1945 is notable for the great number of bison skeletons and for the considerable number of associated artifacts of a distinctive type, differing in some respects from those previously found with fossil bison. The new Texas locality is within the limits of the city of Plainview, in Hale County, about 200 miles directly south of the south-western corner of Kansas.

"The bone bed, ranging in thickness from a few inches to one and one-half feet, was excavated during 1945. It is found

in a former stream channel of Running Water Creek at the base of a valley fill. At the top of the bone bed the bones are more or less broken, while at lower levels and at the bottom the bones are usually complete and often in articulation. Whole skeletons are preserved, but are difficult or impossible to separate entirely from associated skeletons. The accumulation of bison skeletons may have resulted from a bison stampede. Excavation of 62 running feet (about 500 square feet) of the bone bed yielded parts of all of skeletons of between 50 and 100 bison, together with 27 artifacts. The artifacts include 19 projectile points (9 broken), 1 end scraper, 5 side scrapers or knives, and 2 flake scrapers. The projectile points are of the general Folsom-Yuma complex, but are distinctive in character and have been designated the Plainview projectile. Measurements (not yet completed) have shown that the bison of this quarry is notably larger than the largest individuals of the modern species. Measurement from tip to tip of horn cores of an adult individual is 875 mm. It is a coincidence that the fossil bison discovered in Kansas by Martin and Overton has the same measurement of spread of horns.* The only other vertebrate found in the bone bed is a large wolf. Fresh water invertebrates are present. The catastrophe to the bison herd occurred in late winter or early spring, as indicated by the presence of unborn calves. Animals of all ages from young to old were in the bison herd. From nearby localities in the valley fill there have been obtained bones of fossil elephant and horse, and an end scraper used by man in cleaning hides.

"Participating in this investigation, in addition to the writer, are Glen Evans, Grayson Meade, Richmond Bronaugh, and Alex Krieger. A more complete account of this discovery is in preparation. The artifacts and a mounted skeleton of the fossil bison will be placed on exhibit in the Texas Memorial Museum at Austin."

*The horn core measurement for large modern buffaloes varies from 600, or less, to 650 or 660 mm. as a maximum.

Dr. Sellards, the author of the above report, is a former Kansan, having taken his baccalaureate and master's degrees from the University of Kansas at the turn of the century. In writing to the editor, Dr. Sellards contributed the following interesting information bearing on the past history and value of the Academy:

> During my student days and later as assistant in the Kansas Geological Survey, the Kansas Academy of Science accepted and published my first feeble papers, for which I have always been grateful. Mrs. Sellards' grandfather, Joseph Savage, was an early member and contributor to the activities of the Academy, and some of the collections made by him and described in the Academy publications are still in my possession, having come to me as a gift from another Academy member, Mary Savage (Mrs. Joseph Savage).

Dr. Hobart M. Smith, for the past semester acting assistant professor of zoology at the University of Kansas, has accepted a position with the fish and game department at Texas A. and M. College, College Station, Texas. Dr. Smith began work

at the College on February 4th and will teach courses in herpetology and icthyology and allied fields and will also take part in teaching and management of the Texas program of wildlife conservation.

Dr. Shelby A. Miller, formerly a member of the du Pont Experimental Station staff has been appointed associate professor of chemical engineering at the University of Kansas and will begin his duties at the University about April 1. Dr. Miller is a graduate of the University of Louisville and received his doctorate from the University of Minnesota in 1940.

Dr. Harold C. Hodge, formerly professor of chemistry at Ottawa University and still an Academy member, is now an associate professor at the University of Rochester, Rochester, N. Y. During the war, Dr. Hodge was engaged in research on the medical aspects of the development and use of the atomic bomb.

Dr. R. E. Mohler, professor of biology at McPherson College, is enjoying a semester's leave of absence from his college teaching. Dr. Mohler is spending his leave in Los Angeles and is devoting his time to studying and writing.

Dr. L. J. Lyons, for the past three years instructor in science at Fort Scott Junior College, has resigned his position to become head of the biology department at Sioux Falls College, Sioux Falls, South Dakota.

Mr. Robert Taft, Jr., for the past two years graduate assistant in chemistry at the University of Kansas, has resigned his position to accept a similar one at Ohio State University, Columbus.

In the weeks elapsing since our last issue some fifty science teachers among the high schools of the state have become members of the Academy. We welcome these new members to our organization, offer them a special invitation to attend any or all sessions of the annual meeting at Emporia on April 11-13, 1946, and request them to write the editor if they have suggestions that will make the *Transactions* more useful to the high school group. The general plan of each issue of the *Transactions* is to publish a feature article of general scientific interest. This article is followed by editorials and news notes describing scientific events, personal items and book reviews, especially those of interest to Kansans who teach and work in the various scientific fields; concluding each issue will be found a number of professional papers in a variety of fields.

Dr. John C. Frye, assistant director of the State Geological Survey, attended a conference sponsored by the Colorado Mining Association in Denver on January 24, 1946. The topic of the conference dealt with mineral reserves of the West and was attended by representatives from 16 states. Dr. Frye addressed the conference on "Kansas Mineral Reserves."

Messrs. J. W. E. Stogsdill and

Clinton A. Kaufman, both of Wichita High School East, have been teaching evening classes in physics at Friends University during the absence of Mr. Kenneth Andrew, professor of physics at Friends, but now in the service.

The Rocky Mountains, Wallace W. Atwood, (The Vanguard Press, 1945, 324 pages, $3.75) is an account of Rocky Mountain geology, of personal experience acquired in a twenty year interval of mountaineering and geological exploration, of Rocky Mountain mining and Indian history, and of Rocky Mountain national parks. Simple and lucid writing among scientific men is a rare talent, and any member of the scientific profession who has any hopes of presenting his studies to a wide audience will do well to study this volume for style alone. This book, however, is much more than a style manual. It will lend enjoyment and understanding to those of us who are frequent visitors to the Rockies. In addition to this, reading a stray paragraph here and there through this book brings momentary release from the cares of the present. Take this brief paragraph, for example:

> Many are the joys of the trail, but none compares to the comfort and delight of camp and the end of the day's ride. The healthy fatigue of the trip falls away the moment the tents are raised and the smell of the wood fire fills the grove of aspens or the dense conifers selected for the night's rest. A cool breeze from the heights fills the canyon There is the friendly sound of the stream. There is happy relief from the saddle. Some lie on the ground, resting and within scent of the preparing meal. One enthusiast tries for trout in the stream. But all have a contentment that is blessed. The contentment is in sympathy with the horses and pack animals feeding in a meadow.

The enjoyment in reading this book is enhanced by many excellent photographs, and by a number of equally excellent black and white "atmosphere" sketches drawn by Eugene Kingman. Dr. Erwin Raisz has contributed a relief map of the Rockies and eight cross-section drawings that aid greatly in understanding President Atwood's discussion of Rocky Mountain geology. A four-star book for the general scientific reader—and it doesn't take much scientific training to understand it, so clearly is it written.

Miss Eunice L. Kingsley, assistant professor of botany at Kansas State College, Manhattan, will return to the College to resume her teaching duties beginning with the summer session of 1946. Professor Kingsley has been absent on leave from the College for the past two years.

Capt. Frank Bryne, after three and a half years' service with the U.S. Air Corps, has returned to his duties in the department of geology, Kansas State College, Manhattan. Dr. Bryne reports that his work consisted chiefly of giving instruction in instrument calibration, camouflage, and the interpretation of aerial photographs. The most interesting part of his work consisted in making many flights over "a good part of the United States and our allied country, Texas."

George Henry Failyer, the oldest Academy member from the standpoint of service, died in Manhattan on October 16, 1945, at the age of 96. Professor Failyer joined the Academy in 1878 and in his younger days was active in Academy work, serving on many committees and in several offices, becoming president in 1890. A fuller account of his life will be given in volume 49 of the *Transactions.*

Mr. Harry Rosenstein, for the past year a research associate in the University of Kansas Research Foundation, has resigned his position to accept a place on the research staff of the Imperial Wall Paper Co., Glenn Falls, New York.

Dr. David N. Hume, who was appointed assistant professor of chemistry at the University of Kansas in 1944 and who has since been on leave working on the now famous Manhattan project at Oak Ridge, Tennessee, has reported for service at the University and began work with the spring semester. Dr. Hume was in charge of the analytical section, chemical division, of the Clinton Laboratories at Oak Ridge and will be in charge of the work in analytical chemistry at the University. He is a graduate of U.C.L.A. and received his doctorate from the University of Minnesota in 1943.

Major Leonard F. Hartman, who served with combat engineers in France and Germany, has been appointed research assistant in the chemical engineering department at Kansas State College, Manhattan. Mr. Hartman, a graduate in chemical engineering from the Michigan School of Mines, will work on a Procter and Gamble research project, studying the fundamentals of spray drying, a method used in the manufacture of soap to eliminate moisture content.

Mr. Allen R. Roberts, now a member of the U. S. Army and stationed temporarily at San Francisco, writes, "My main interest is zoology and particularly herpetology. I am stationed near San Francisco and have done a great deal of collecting. Perhaps there are other Academy members who would be interested in receiving some of the fine specimens I've collected. If so, they can get in touch with me through my home address." Mr. Roberts' home address is 2900 Tyler Avenue, Detroit 6, Michigan. We hope that there are members of the Academy who will take advantage of Mr. Roberts' generous offer; not only because it will be of advantage to the receiver but because it will aid in keeping Mr. Roberts' scientific interest alive and will aid in keeping him in touch with the Academy.

Birds in Kansas, by Arthur L. Goodrich, by the time this issue of the *Transactions* reaches our members, will probably be available for distribution. The book of 340 pages is another monograph which the Kansas State Board of Agriculture has had the wisdom to publish in recent years. *Flowers in Kansas, Weeds in Kansas, Trees in Kansas, Grasses in Kansas,* and *Insects in Kansas* have been other members of this series and have proved so useful and popular

that two are now out of print. *Birds in Kansas* contains a description of 366 species of birds of Kansas, although no definition of this term (birds of Kansas) is made by Dr. Goodrich other than, a "Selected List of More Common Kansas Birds". In addition to the descriptive list, there are sections devoted to "Birds and Mankind", "The Life of a Bird", and "The Body of a Bird", all of which will prove useful to those Kansans interested in the observation and study of bird life. The book is illustrated with 169 figures in text and by six color plates of the eastern sparrow hawk, the prairie chicken, the eastern cardinal, the western meadowlark, red-eyed towhees, Carolina wren, and Kentucky, black-poll and prothonatory warblers. These color plates are the work of the well-known Topeka artist, Miss Margaret Whittemore. Copies of *Birds in Kansas* may be secured by addressing Mr. J. C. Mohler, secretary, Kansas State Board of Agriculture, Topeka.

Although not impairing the book for the use of many readers, the almost complete lack of bibliography in this volume is to be regretted. The very extensive work of F. A. Snow and N. S. Goss is only mentioned in a sentence in Dr. Goodrich's "Acknowledgments" and no description is given of the form of their publications. The very important work of W. S. Long is likewise mentioned but citation to Long's published work is buried in a footnote on page 215. Long's original work, a master's thesis completed in 1935 at the University of Kansas, contains a bibliography of over 230 items relating to the birds of Kansas, a very considerable number of the original articles appearing in these *Transactions*. Although no such extensive bibliography as Long's would be necessary in Dr. Goodrich's book, a concise biliography, it appears to the editor, would have increased its usefulness greatly. As a supplement to the work of Dr. Goodrich, we may possibly publish Long's bibliography in a future issue of these *Transactions*.

The Baldwin Bird Club (Baldwin, Kansas) organized over a year ago, now has a membership of twenty. A number of the members belong to the faculties of the local high school and of Baker University. All persons interested in the study of bird life are invited to attend the meetings of the Club and correspondence with bird clubs in other parts of the state is desired. Dr. Ivan L. Boyd, professor of biology at Baker University, is president of the Club.

Museum of Natural History, University of Kansas is the title of an illustrated 16-page booklet descriptive of the Museum collections. In picture and word the character and the importance of the exhibits and materials owned by the Museum are explained for the public. Copies of this handsome bulletin may be obtained for a mailing fee of five cents by addressing the Director, Museum of Natural History, University of Kansas, Lawrence.

Dr. Albert C. Spaulding becomes instructor in anthropology at the University of Kansas and

assistant curator of anthropology in the Museum of Natural History. The anthropological and archeological collections of the Museum, and especially the valuable Indian materials will thus be in charge of a specialist. Dr. Spaulding is a graduate of Montana State University, the University of Michigan and of Columbia University, having received his doctorate at Columbia in 1942. From 1942 to 1945, Dr. Spaulding worked as a civilian in the War Department and the hydrographic office of the Navy on war topographic mapping.

The well-known Ellis Library of some 60,000 volumes was bequeathed to the University of Kansas upon the death of the owner, Mr. Ralph Ellis. Mr. Ellis died on December 17th, 1945, at Colusa, California. The Library, begun originally through Mr. Ellis's interest in ornithology, became eventually a library of natural history and as such it will be a valuable aid and an important resource for research and teaching in the University's Museum of Natural History. The Library includes such items as complete sets of Gould's works on *Birds of the World* and an unusually complete collection of Linnean material. Also included are numerous rare bird prints in elephant folio, both colored and uncolored; in addition some of the original lithographic stones from which Gould's work was printed are included. Before the Library can reach its maximum usefulness it must be catalogued, a process, it is estimated,that will require the work of a full-time librarian and assistant for two and a half years. The Library is one of the most important scientific gifts that has ever been received by Kansas and all Kansans should be deeply appreciative of the gift.

Dr. Donald S. Farnar has been appointed assistant professor of zoology at the University of Kansas and assistant curator of birds in the Museum of Natural History. Dr. Farnar's appointment fills a long felt need at the University for a competent ornithologist. He is a graduate of Hamline University and received his doctorate from the University of Wisconsin in 1941. For several years he was an instructor in zoology at Wisconsin but more recently he was in the U. S. Navy as a member of the Typhus Commission.

On January 10 of the present year, Dr. E. R. Hall, Dr. Hobart Smith and M. Maladonado-Koerdell of the University Museum of Natural History, visited Ottawa University (Kansas) to examine the very excellent collection of salamanders in the University museum. The collection at Ottawa was formed largely through the efforts of Dr. H. K. Gloyd, a former student of Ottawa. M. Maldonado-Koerdell plans to publish shortly a catalogue and description of salamanders in Kansas museums.

Kappa Chapter of Phi Sigma, honorary biological society held its annual dinner at the University of Kansas on December 3, 1945. Thirteen members were initiated. Dr. A. I. Ortenburger, professor of zoology at the University of Oklahoma, national

chancellor of the Society made the principal address at the initiation. Dr. Ortenburger, in the afternoon preceding the initiation program, delivered a public address, "The Salt Plains of Oklahoma."

A number of members of the University of Kansas staff attended the annual meeting of the Geological Society of America in Pittsburgh, Pennsylvania, December 27-29, 1945, the first annual meeting of the Society held since 1941. Members present from the Museum of Natural History included Dr. Claude Hibbard, Dr. Donald Hoffmeister, and M. Maldonado-Koerdell; from the State Geological Survey, Dr. J. C. Frye, Miss Ada Swineford, Dr. R. C. Moore, Mr. R. M. Jeffords, Prof. L. R. Laudon, and Dr. M. L. Thompson.

Following the meeting of the Geological Society, Dr. Hibbard went further east for studies at the U. S. National Museum, the Philadelphia Academy of Sciences (to examine some of the famed Cope's type specimens), the American Museum of Natural History in New York and the Museum of Comparative Zoology at Harvard University. Dr. Donald Hoffmeister studied in the Carnegie Museum in Pittsburgh, the U. S. National Museum in Washington, the American Museum of Natural History and the Chicago Natural History Museum. Dr. Hoffmeister examined and studied cricetine rodents (native North American rats and mice) in both fossil and recent forms and also studied methods employed for housing and curating natural history research specimens in these museums. M. Maldonado - Koerdell, Latin - American Guggenheim fellow (1944-46) at the University of Kansas, examined and studied skeletons in the collections at the Carnegie Museum in Pittsburgh of ambystoma (salamanders) and type material in the same field at the U. S. National Museum.

Dr. A. J. Mix, professor of botany at the University of Kansas, has returned to the University after leave of absence beginning in November, 1944. Until July 1, 1945, he was employed by the Plant Disease Prevention division of the U. S. D. A., Newark, Delaware, and made surveys in Delaware, Maryland, and New Jersey. Beginning July 1, 1945, he was engaged in research on the physiology of certain cellulose - destroying fungi (cloth destroyers) for the Philadelphia Quartermaster Depot of the U. S. A. The project was carried out at Pennsylvania State College.

The fifty-sixth annual meeting of the Nebraska Academy of Science will be held at the University of Nebraska Medical College, Omaha, on May 3 and 4, 1946. The Nebraska Academy is making plans to publish again its transactions, which have not been issued in recent years.

Son of the Wilderness by Linnie Marsh Wolfe (Alfred A. Knopf, New York, 1945, 364 pp., $4.25) is the biography of John Muir, one of America's greatest conservationists. Muir, born in Scotland in 1838, came as a

youngster to this country with his family in 1849 and settled in central Wisconsin, then frontier country. Despite harsh living conditions rendered doubly harsh by an austere father, a religious fanatic, the bogs and woods made so profound an impression on the life of Muir that in after years he could look back and say "Oh, that glorious Wisconsin Wilderness." His boyhood experiences doubtless determined his career.

Muir spent several years in the early 1860's at the University of Wisconsin where he became interested in the work of Agassiz on glaciers, another factor of importance in Muir's later career. Although possessed of unusual mechanical skill and inventive genius, Muir deliberately turned aside from the use of these talents and became a wanderer, many of his travels taking him to the wilderness. In 1868, he turned up in California and there he made his home until his death in 1914. His life in the Sierras, his studies of glaciation, and his efforts to create the Yosemite National Park and other national reserves are treated in this biography in an understanding and sympathetic manner. Muir, the friend of several U. S. presidents and others of national prominence, was not a simple man but neither was he an affected nor a sophisticated one. He was a prolific writer and traveller and his intimate studies of Sierra glaciers lead to a theory of the formation of many mountain valleys totally different than that held by the leading geologists of his day; but Muir's intimate contact and exhaustive study of many glaciers lead to the theory which in the main is accepted today. His conservation policy was essentially an esthetic one—save the scenic wilderness for its beauty. This idea was not only a theoretical policy in Muir's life; it was also a practical one. Whenever discouraged or in ill health he retired to the wilderness to regain serenity and vigor. "There must be places for human beings to satisfy their souls" he once wrote a friend, and the beauty of the mountain wildernesses he believed to be such places.

To all who are interested in the conservation movement, either past or present, this book should be a most welcome and fascinating one.

The history of six ancient and buried Kansas hills in northeastern Barton County was reported at the December meeting of the Geological Society of America bv Dr. Robert F. Walters of the Gulf Oil Corporation of Tulsa, Oklahoma. A technical abstract of Dr. Walters' report will be found in the *Bulletin of the Geological Society of America* (volume 56, p. 1210, December, 1945) but Dr. Walters, at the editor's request, has kindly prepared a brief review of his work for the *Transactions*. "My report" writes Dr. Walters, "describes the geological history of six hills of Pre-Cambrian quartzite during the 550 million years from Cambrian time to the present. Erosion in late Pre-Cambrian and early Cambrian time left areas of resistant quartzite as residual hills. When the Cambro-Ordovician seas invaded

central Kansas, these hills became islands during the time that the lower Arbuckle beds were deposited. They were buried under the upper Arbuckle beds and younger sediments. During early Pennsylvanian time, erosion exhumed the tops of five of the hills and they were again topographic features on the landscape of central Kansas. As the Pennsylvanian seas, in turn, transgressed across the area these five resurrected hills became diminishing islands. They were buried under marine limestones of middle Pennsylvanian age (Lansing-Kansas City Group) and have remained buried since that time. Their summits are now about 3,-300 feet below the present ground surface. Oil is produced from the Arbuckle dolomite beds surrounding these buried hills, from the Cambro-Ordovician residual sands and the basal Pennsylvanian sands on their flanks, and from the Lansing-Kansas City limestones directly above their summits. The area mapped, which includes the extensive Kraft-Prusa Field, the Beaver Field, the north end of the Bloomer Field, and which extends into western Ellsworth County to include the northern half of the Stoltenberg Field, has produced over 30 million barrels of oil." Dr. Walters' paper will be published in full with maps and detailed cross sections in *The Bulletin of the American Association of Petroleum Geologists* during 1946.

Mr. Morton Green, who has contributed several articles to the *Transactions* in recent years, but who has been in the U. S. Army for over four years, arrived in New York City on Christmas day. Upon release from the Army, he expects to begin graduate studies in zoology at the University of California.

Dr. Claude W. Hibbard, president-elect of the Academy and curator of vertebrates at the Museum of Natural History, University of Kansas, was honored by election to the 1945 class of Fellows of the Geological Society of America at the December, 1945, meeting of the Society.

The southwestern division of the American Association for the Advancement of Science (including the states of Colorado, Arizona, New Mexico, Texas west of the 100th meridian, Chihuahua and Sonora in "old" Mexico) will hold its spring meeting with the national organization in St. Louis on March 27-30, 1946, according to word received from the secretary of the southwestern division, Dr. Frank E. E. Germann of the University of Colorado. The last separate meeting of the division was held at Las Cruces, New Mexico, in 1942 but, beginning again in 1947, it is hoped that division meetings can again be held in the southwest. Despite the fact that the division has had to transact its business solely by correspondence during the war years, its membership has increased from 390 in 1942 to 475 in 1945.

Lambda chapter of Beta Beta Beta, national honorary biological fraternity, was installed at William Jewell College, Liberty, Missouri, within the past few weeks. Dr. W. D. Burbanck of

Drury College, Springfield, Missouri, was the installing officer. The twenty-three members installed and four alumni members constitute the chapter at present. Dr. Burbank delivered an illustrated lecture "The Marine Biological Laboratory at Woods Hole" at the installation banquet.

Dr. E. H. Taylor, professor of zoology at the University of Kansas, has returned from a two years' leave spent in southern and eastern Asia, and in islands to the south of Asia acting in an advisory capacity in connection with problems of the U.S. Army. Dr. Taylor began his teaching duties at the University with the beginning of the current semester.

Dr. Amos Lingard and Dr. James Ingle, former Kansans, are now in the employ of Swift and Company, Chicago, in the division of physics and physical chemistry. Dr. Ingle, recently returned from the Pacific theatre of war, through good fortune and intelligence attained the rank of lieutenant-colonel; the silver eagles, however, have now given way to test tubes.

Dr. R. M. Dryer, assistant professor of minerology and petrology in the department of geology at the University of Kansas, has returned to the University after a two and a half year leave spent with the U. S. Navy. Dr. Dryer began his teaching duties with the beginning of the spring semester.

Dr. R. C. Moore, director of the State Geological Survey, left for Peru on February 4th for a six weeks' oil exploratory trip under the auspices of the Gulf Oil Corporation. Most of the exploration was done by aerial photo-reconnaissance and mapping.

Publications of the State Geological Survey of Kansas, published since our last issue, include:

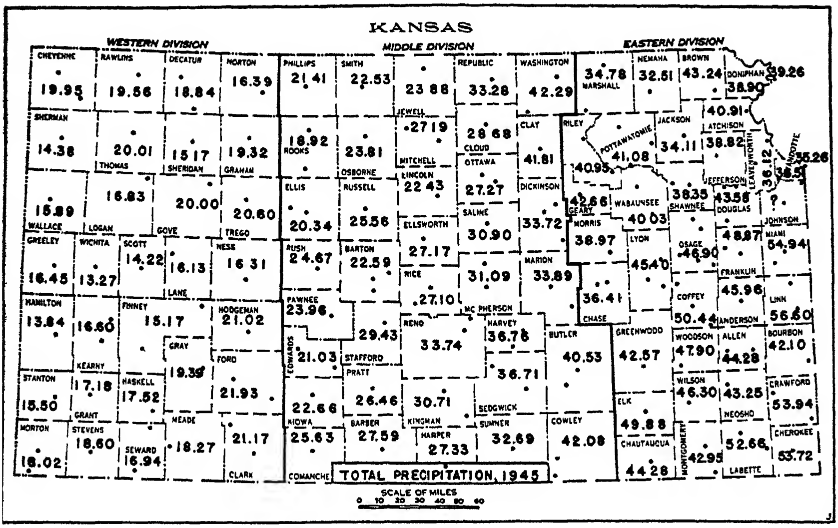
Bulletin 60, Part 3, *Valley Erosion since Pliocene "Algal Limestone" Deposition in Central Kansas* by John C. Frye; 16 pages (serial pages 85-100) one plate and 2 figures, December 1945. Observations of Algal limestone, a thin discontinuous deposit occurring on top of the Ogallalla formation have been recently found on top of the Saline-Smoky Hill Divide in Russell, Lincoln and Ellsworth Counties. Dr. Frye furnishes an interpretation of the newly observed localities of the Algal limestone for measuring erosion in post-Ogallala time. Copies of the bulletin may be secured for a mailing charge of 10 cents by addressing the State Geological Surveys, Lawrence, Kansas.

Bulletin 60, Part 4, *The Cheyenne Sandstone and Adjacent Formations of a Part of Russell County, Kansas* by Ada Swineford and Harold L. Williams with analyses of ground water by Howard Stoltenberg; 68 pages (serial pages 101-168), two plates and nine figures, December 1945. The study is based on drillings from oil test holes in the area studied. Copies may be obtained from the State Geological Survey for a mailing cost of 10 cents.

Kansas Weather: 1945*

S. D. FLORA
U. S. Weather Bureau, Topeka

The year 1945 was characterized by an excessively heavy precipitation over the eastern half of Kansas which caused numerous and destructive floods, besides interfering seriously with farm work, but the western third of the State was inclined to be dry. Comparatively cool weather through April, May, June and July and an unusually cold December resulted in the mean temperature for the year being slightly below normal.



Rainfall values are for individual stations in each county and are not county averages. The question mark for Johnson County indicates that complete data are not available.

The average precipitation over the eastern third of the state was 43.03 inches; the middle third, 30.05 inches; the western third, 17.56 inches; and for the State as a while, 30.20 inches, which was 3.29 inches above normal but 7.27 inches less than the average for the previous year. Over most of the eastern third, where it was the 7th wettest year on record, most stations reported totals in excess of 40

Transactions Kansas Academy of Science, Vol. 48, No. 4, March, 1946.

*This summary of Kansas weather is based on *Climatological Data*, Kansas Section, U.S.D.C., 1945, where more detailed meteorological records are also available.

inches and a number of places had more than 50 inches. The middle third, while 3.60 inches above normal in precipitation, had 7.74 inches less than in 1944, while nearly all the western third showed a deficiency. The greatest total rainfall reported was 56.60 inches at La-Cygne, Linn County, and the least, 13.84 inches at Syracuse.

Snowfall averaged approximately 50 % above normal and has been exceeded in only five of the previous 57 years of state records. No year between the time when state-wide records were begun in 1888 and 1912 had as much snowfall as this year, which refutes a general belief that show is not as heavy as a generation or two ago.

The mean temperature of the year, 54.6°, was 0.4° below normal and the lowest since 1929 although this record was tied in 1937 and 1940. The warmest month was August and the coldest, December. The highest temperature recorded was 110° at Medicine Lodge on August 3 and at Lincoln on August 13. The lowest was 24° below zero at Horton on December 19.

The year began with comparatively mild, wet, and excessively cloudy weather that extended through March. April, May, and June were also excessively wet and cloudy in the eastern part of the State, which resulted in farm work and spring planting being greatly delayed with near record overflows along the Marais des Cygnes, Neosho, and Verdigris Rivers, and with frequent overflows of other streams in the eastern part of the State. The spring and early summer months were, however, very favorable for wheat.

Heavy rains well in the eastern half of the State in July, but the western half was becoming dry. Excessively hot dry weather in August and the first three weeks of September caused a general deterioration in corn, grain sorghums, and pastures. This drought was relieved in eastern Kansas by soaking rains during the closing week of September, but October and November were mild and dry, which gave the wheat crop a poor start, though the State was favored by some very pleasant Indian-summer weather. December, with its heavy snows, furnished an abundance of moisture except in the western counties.

More detailed accounts of 1945 wind and hail storms and of floods, followed by summaries of weather conditions for individual months are given below.

Severe Windstorms

Seventeen tornadoes and 21 severe windstorms of other nature were reported during the year, but no loss of life occurred and the

damage from most of these was comparatively small. By far the greater number of them occurred in May and June.

Total damage from tornadoes was estimated at about $292,000. The most destructive of these was a family of tornadoes that struck Butler and Cowley Counties on June 30, with a loss of $110,000. The principal damage was to rural buildings and crops. Eight funnels were reported.

Loss from violent windstorms not classed as tornadoes, insofar as estimated, was $2,836,500. More than half of this loss was in connection with a storm that occurred in Russell County on June 26, which was reported to have caused damage totalling $2,000,000. Heaviest losses were between Gorham and Russell and in the Trapp oil fields south of Bunker Hill. Hail occurred in connection with this storm.

Hail

Hail damage was among the greatest, if not the greatest, in the State's history. A total of 85 severe falls of hail was reported, with damage, insofar as estimates are available, totalling $10,698,500. Many smaller losses, of course, were not reported. A report of the Western Hail and Adjustment Association, in summing up hail risks and hail losses for a large number of companies doing business in Kansas, computed the ratio of loss to risk as 7.17 per cent as compared with 5.38 per cent for the five-year average, 1941-45, and 4.58 per cent for the 31 years ending with 1945.

Three hailstorms of the year resulted in estimated losses of $1,000,000, or more each. The most severe of these occurred in Decatur County on June 30, with an estimated loss of $1,500,000, making it among the most destructive storms in the State's history. Damage extended almost all the way across the county. In many places crops were completely destroyed. Hailstones were so large they penetrated roofs of houses north of Oberlin and drifts were still in evidence in draws 48 hours after the storm. Two other hailstorms of the year caused losses estimated at $1,000,000 each. One occurred in the eastern part of Sherman County on May 30 and the other cut a swath across Thomas County, from the northwest to the southeast, on June 30. Chief damage from these was to wheat.

Overflows of 1945 in Kansas

Overflows that ranged in intensity from moderate to very severe occurred in all streams of the eastern half of the State from

April to July, inclusive, and were near record-breaking in April along the Marais des Cygnes (Osage), Neosho, Verdigris, and the Little Arkansas. Other overflows occurred in the southeastern and south-central parts of the State in September and October.

The total flood damage of the year in the basins of the major rivers of the State was estimated at $6,217,980, approximately half of which was in the basins of the Marais des Cygnes (Osage), Cottonwood, Neosho, and Verdigris Rivers.

The Marais des Cygnes (Osage) overflowed its banks four times at Ottawa and five times at Quenemo and Trading Post, reaching a stage of 36.2 feet at Ottawa on April 16, which compares with 36.5 feet in April 1944 and 37.6 feet in November 1928, the two greatest floods of record at that place. The total damage along the Marais des Cygnes (Osage) River in the State was estimated at $1,000,930.

The great overflow of the Cottonwood and Neosho Rivers very nearly equalled the great flood of April 1944 and was almost as high as the great flood of July 1904. From Chanute to Oswego it exceeded the flood of September 1926. At Emporia a crest of 27.4 feet, only 0.3 foot below the highest crest of record, in April 1944, occurred. At Iola the crest was 22.4 feet, which was only 0.2 foot lower than the crest of April 1944, and at Parsons the crest was 29.0 feet, which was only 0.7 foot lower than the greatest flood of record at that place, in April 1944, and at Oswego an all-time high stage of 25.98 feet was reached. The total damage of these April overflows along the Cottonwood and Neosho Rivers was estimated at $1,074,050. Another general overflow of these rivers occurred near the close of September and the fore part of October, which, with damage in other streams of the southeastern and south-central parts of the State totalled $1,063,350.

The Verdigris River reached a crest of 47.3 feet at Independence on April 17, which was the second highest crest at that place, being exceeded only by a crest of 47.6 feet in May 1943. Damage from this overflow along the Verdigris was estimated at $979,300.

The Kansas River overflowed six times at Topeka and Lawrence and eight times at Manhattan during the year. The first of these overflows occurred in April and last in July. No especially high stages occurred, however, and the total damage for the year, including damage in the Delaware Basin, was estimated at $654,900.

The Blue River also overflowed frequently, exceeding bankful stage five times at Blue Rapids and four times at Randolph. The

most serious of these overflows occurred in May, when a crest of 32.75 feet, 12.75 feet above bankful, was recorded at Blue Rapids on May 22.

The Little Blue River also overflowed at least four times but did not reach especially high stages. Loss along the Big and Little Blue Rivers for the year was estimated at $355,000.

The Republican River overflowed its banks at Clay Center eight times from April to July, inclusive, and three times at Junction City, but here, again, no especially high stages occurred. Damage along this river for the year was estimated at $111,000.

The Solomon River overflowed its banks four times at Beloit and three times at Niles, although no near record-breaking stages occurred. Damage along this stream was estimated at $131,700.

The Smoky Hill River overflowed its banks three times at Lindsborg, Abilene, and Enterprise during the year but only once at Salina. The highest stages along this stream were near its lower reaches, where Enterprise reached a crest of 29.76 feet on July 18, which was only 0.3 foot lower than the flood of October 1941, the greatest on record at that place since 1903. Damage along this river was estimated at $270,750.

The Walnut River reached a stage of 35.93 feet, 5.93 feet above bankful, at Winfield on April 17, with damage estimated at $309,000. In an overflow which began the closing days of September and continued into October, a crest of 35.0 feet was reached at that place on September 30. Damage from this latter flood was included in estimates of all rivers in this part of the State.

The Little Arkansas reached a record-breaking crest of 24.8 feet at Sedgwick on April 16. This was 0.6 foot higher than the previous greatest flood of April 1944. Damage from this overflow was estimated at $268,000.

Another serious overflow along this river occurred during the closing days of September, with a crest of 24.1 feet on September 28.*

SUMMARY BY MONTHS

January

Excessively damp weather prevailed this month, with heavy snows in the western part of the State, which were very favorable for the wheat crop but held farm work almost at a standstill. Tem-

* Estimates given above are preliminary and are subject to later revision. It is also possible that there may be slight changes in some of the crests given when records of the self-registering gages of the U. S. Geological Survey become available.

peratures, as a rule, were mild, with no unusual extremes, but there was less sunshine than usual.

The average precipitation over the eastern third was 0.62; the middle third, 0.93 inch; the western third, 1.10 inches; and for the State as a whole, 0.88 inch, which was 0.19 inch above normal and 0.21 inch less than fell in January one year previous.

Snowfall over the western third generally totalled 8 to 10 inches and, as a rule, covered the ground continually the last two weeks of the month, soaking it well as it gradually melted. Over the eastern half, snowfall was comparatively light and the ground generally bare.

February

Frequent falls of moisture, heavy snows over many areas, and excessive cloudiness made this a very unfavorable month for farm work but fine for the wheat crop.

It was a comparatively mild month, with no zero weather or severe cold waves and a mean temperature for the State which was 2.0° above normal.

The average precipitation over the eastern third was 1.25 inches; the middle third, 1.06 inches; the western third, 0.43 inch; and for the State as à whole, 0.91 inch, which was 0.08 inch below normal and 0.31 inch less than fell in February one year previous. The soil over the State was excessively wet when the month began and remained so until its close, especially over the eastern half.

Field work was at a standstill most of the month and all farm work was behind the season as the month closed.

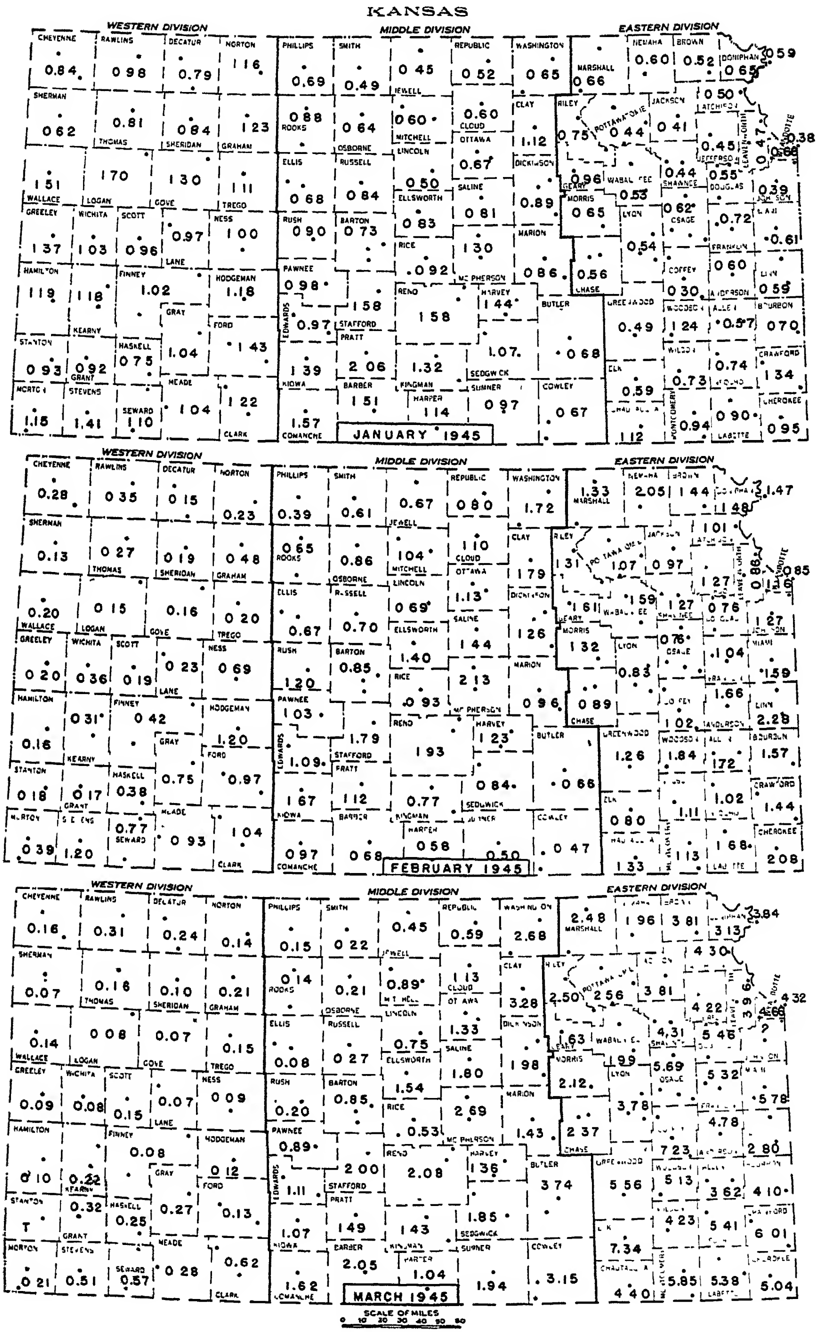
March

This was the fifth mildest March in 58 years, with more sunshiny days than usual and a heavy fall of moisture over the eastern third of the State that has seldom been equalled in any March. In the western counties, however, the fall of moisture was decidedly deficient, generally less than a quarter of an inch.

The average precipitation over the eastern third was 4.23 inches; the middle third, 1.43 inches; the western third, 0.23 inch; and for the State as a whole, 1.96 inches, which was 0.51 inch above normal.

Snowfall was light for the time of year, generally less than an inch, except in the northern half.

Farm work, especially in the eastern part of the State, was greatly delayed by water-soaked fields. Planting potatoes in commerical fields in the Kaw Valley did not get under way until the clos-


KANSAS
WESTERN DIVISION
MIDDLE DIVISION
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JANUARY 1945
WESTERN DIVISION
MIDDLE DIVISION
EASTERN DIVISION
FEBRUARY 1945
WESTERN DIVISION
MIDDLE DIVISION
EASTERN DIVISION
MARCH 1945
SCALE OF MILES

ing week. In the western half the bulk of oats and barley was sown. It was an exceptionally favorable month for the wheat crop.

Slight to moderate overflows occurred along the Marais des Cygnes and in parts of the Neosho and Verdigris Rivers during the month.

April

This month was abnormally cold and excessively wet and cloudy over the State. Near record-breaking floods occurred along the Neosho and Marais des Cygnes Rivers, with overflows in many other streams. Farm work was seriously delayed by wet soil, especially in the eastern half of the State.

The average precipitation over the eastern third was 7.68 inches; the middle third, 6.03 inches; the western third, 3.03 inches; and for the State as a whole, 5.58 inches, which was 2.89 inches above normal and the greatest amount ever recorded in April, except in 1944. Rains fell through the month with a frequency that has seldom been exceeded and in the eastern half kept the soil soaked almost continually.

The month's weather was very nearly ideal for wheat, except that the fore part was a little too dry in some western counties and somewhat too wet in the eastern portion. Corn planting began in the south-central and southeastern counties.

May

Frequent and excessively heavy rains fell over most of the northeastern quarter of the State this month but amounts in many south-central and southwestern counties were decidedly deficient. Serious overflows occurred in both the Big and Little Blue Rivers, with moderate overflows along the Kansas, Republican, Solomon, Smoky Hill, and Marais des Cygnes Rivers.

The average rainfall over the eastern third was 5.39 inches; the middle third, 3.38 inches; the western third, 1.73 inches; and for the State as a whole, 3.50 inches, which was 0.31 inch below normal. Many northeastern counties received totals of 6 to 10 inches.

Temperatures averaged considerably below normal most of the month, while excessive cloudiness in the northeastern portion, which resulted in a backward condition of crops and farm work.

Wheat suffered from dry weather in the southwestern counties and from lack of sunshine and warmth in the eastern part of the

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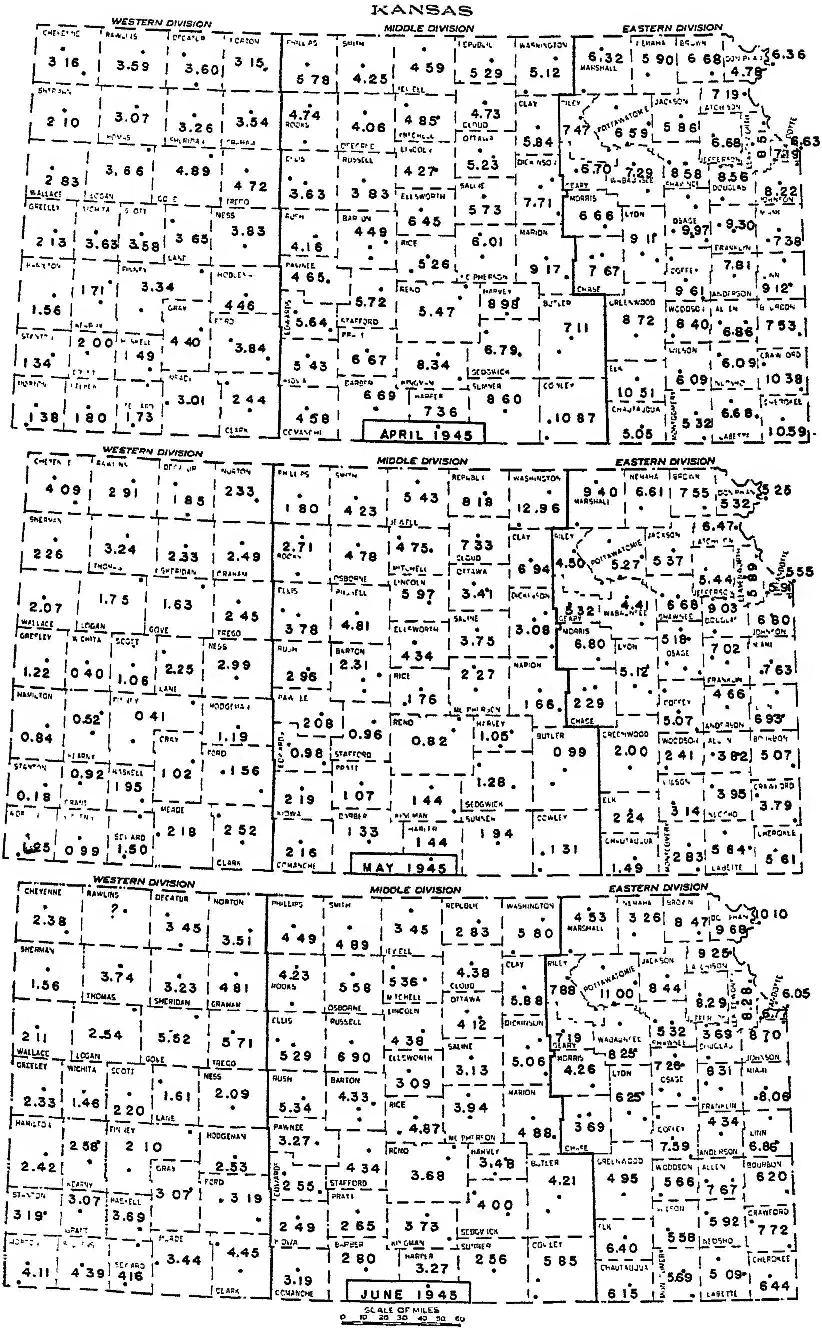
☛ Question marks on monthly rainfall maps indicate that no record is available. "T" indicates a "trace", i.e., less than 0.005 inches. Values given for rainfall in each county are for single stations.


KANSAS
WESTERN DIVISION
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APRIL 1945
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MIDDLE DIVISION
EASTERN DIVISION
MAY 1945
WESTERN DIVISION
MIDDLE DIVISION
EASTERN DIVISION
JUNE 1945
SCALE OF MILES
0 10 20 30 40 50 60

State. The delay to farm work was especially pronounced in the eastern counties. Fifty to 75 per cent of corn had been planted in most southeastern and central counties by the close of the month.

JUNE

Excessively cool, rainy, and cloudy weather prevailed this month, especially in the eastern part of the State. Farm work of all kinds and ripening of wheat were seriously delayed, damaging hail and wind storms occurred in many places, and overflows occurred in practically all streams in the northeastern quarter.

Rains fell with much greater frequency than usual and monthly totals were above normal in almost all parts. The average for the eastern third was 6.80 inches; the middle third, 4.22 inches; the western third, 3.14 inches; and for the State as a whole, 4.72 inches, which was 0.69 inch above normal. This made the total precipitation over the eastern third since the first of the year 25.97 inches, which was 74 % of the normal for the entire year and the greatest amount for the first six months of any year of record, except 1908 and 1915.

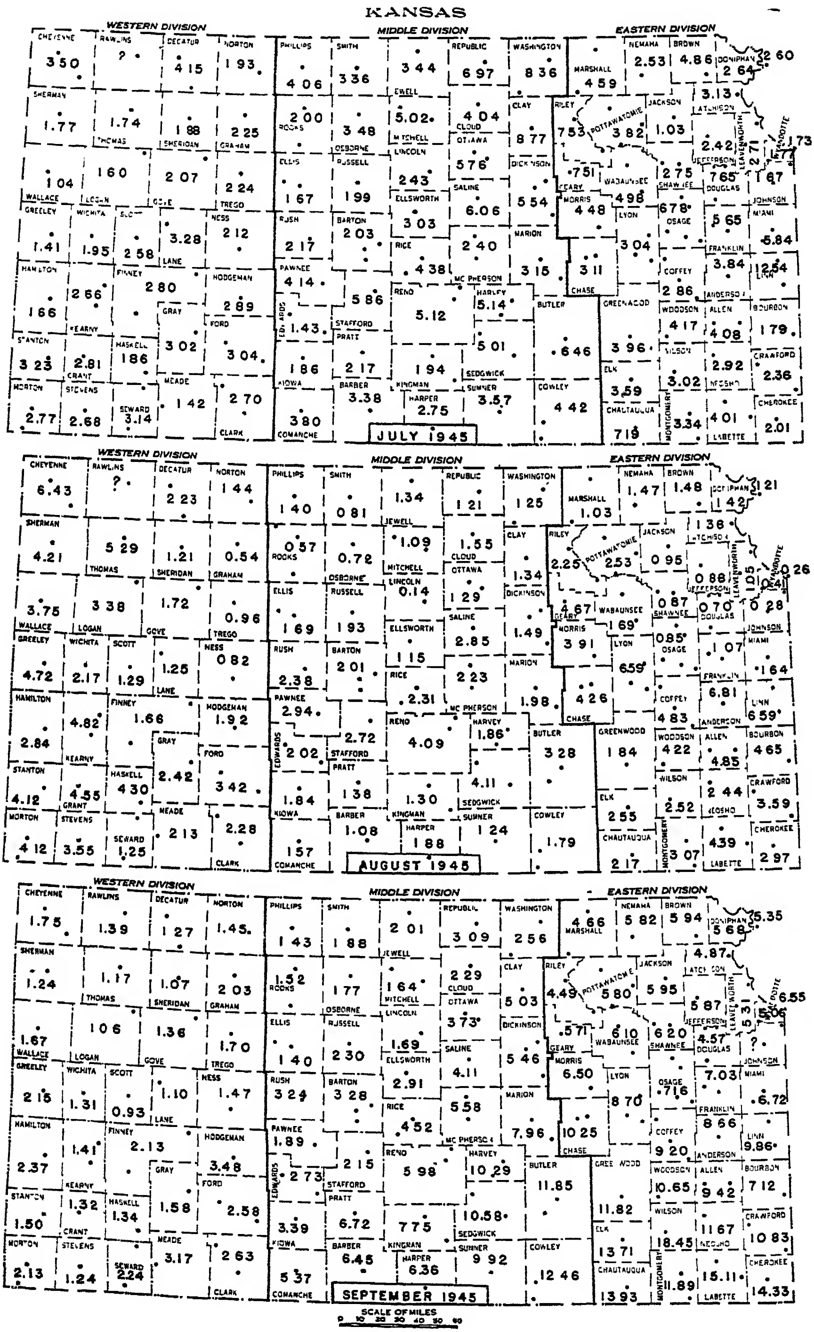
In the eastern half of the State spring work was so seriously delayed by water-soaked fields that a considerable part of the intended acreage of corn was not planted and there was but little opportunity to cultivate what came up. Wheat matured slowly and by the close of the month little had been cut by combines, though harvest by binders had begun in many areas.

JULY

Excessively heavy rains fell over much of the eastern half of Kansas this month but the northeastern counties and most of the western half of the State had much smaller amounts and were becoming dry when the month closed. The first half of the month was cool and cloudy, with frequent rains. The last ten days were abnormally hot, with much sunshine and only infrequent showers.

The average rainfall over the eastern third was 4.26 inches; the middle third, 4.25 inches; the western third, 2.40 inches; and for the State as a whole, 3.64 inches, which was 0.50 inch above normal. Over the western third the fall of moisture was less than half of the amount received in July one year previous.

With the exception of 1927, this was the coolest July in 21 years, although readings of 100° or higher were frequent the last ten days, except in the southeastern quarter. The upper soil dried out rapidly, with the result that corn was in poor condition to stand the hot weather the opening days of the following month.


KANSAS
WESTERN DIVISION
MIDDLE DIVISION
EASTERN DIVISION
JULY 1945
AUGUST 1945
SEPTEMBER 1945
SCALE OF MILES

August

Hot weather and a deficiency in rainfall that extended to most parts of the State were damaging to growing crops in many sections.

Rains were spotted and especially deficient in the north-central and northeastern counties. The two western tiers of counties fared better than any other part of the State, with amounts totalling from two to five inches.

The average for the eastern third was 2.55 inches; the middle third, 1.90 inches; the western third, 2.60 inches; and for the State as a whole, 2.35 inches, which was 0.83 inch below normal, making this the 17th driest August in a 58-year record.

The mean temperature, 78.5°, was 0.6° higher than that of August one year previous. Temperatures above 100° occurred in practically all parts except some northeastern counties and on several days in a large number of places.

Corn was generally needing rain when the month began and, while rains the fore part revived it, the excessively hot weather and little or no precipitation the closing week caused rapid deterioration in many fields.

Plowing for the next crop of wheat progressed rapidly the fore part of the month but by the close the ground was so hard and dry this work was practically suspended.

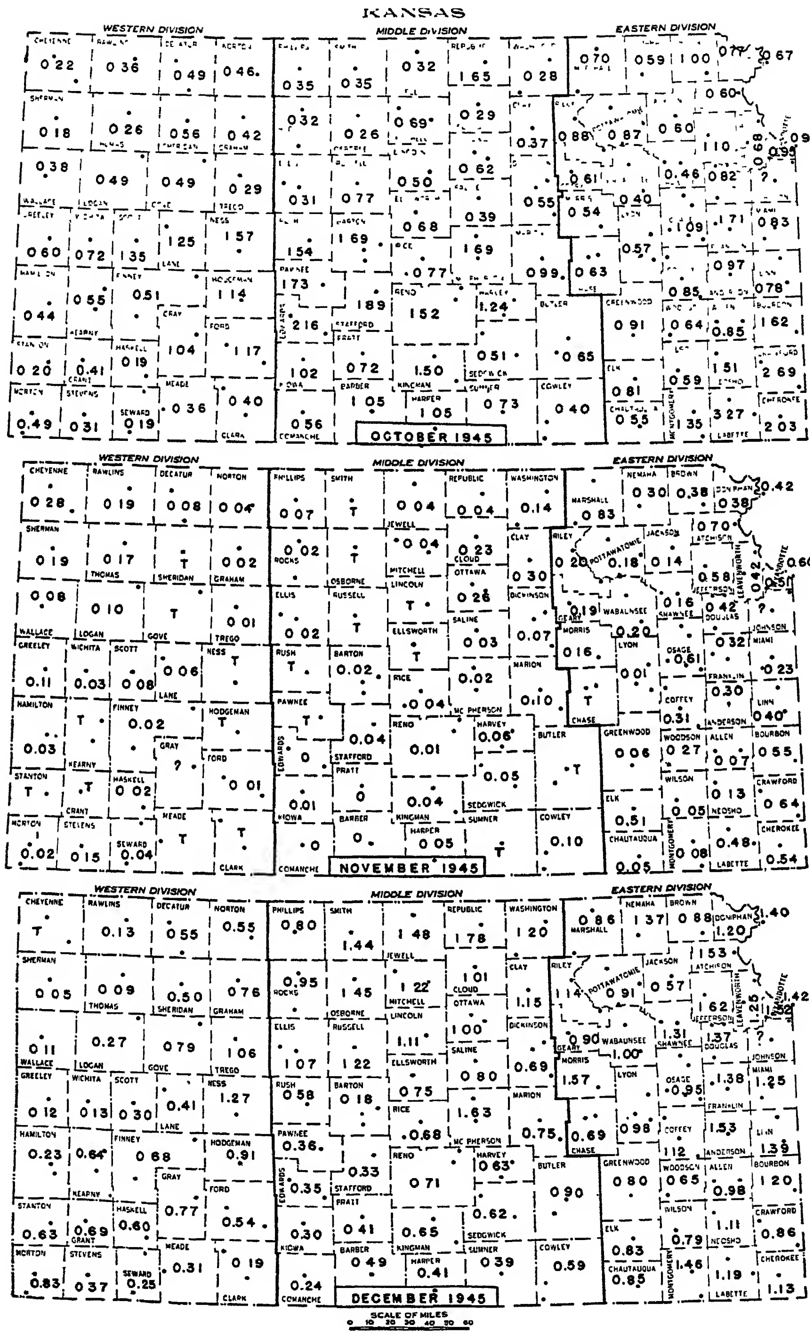
September

Abnormally hot dry weather the first three weeks of this month was followed by prolonged and heavy rains over the eastern third of the State and the south-central counties, with a freeze and light snow in many western counties.

Monthly totals of rainfall in the southeastern counties ranged from 10 to 15 inches or more and resulted in damaging overflows. Many western and north-central counties were needing more moisture when the month ended.

The average for the eastern third was 7.84 inches; the middle third, 5.04 inches; the western third, 1.79 inches; and for the State as a whole, 4.89 inches, which was 2.05 inches above normal. Over the eastern third the average was the greatest for September in 19 years and over the western third it was the greatest for September in four years.

Temperatures the first week rose to 100° or higher on several afternoons over the western two-thirds of the State and close to 100° over the eastern third. On the 28th, and in some instances on the


KANSAS
WESTERN DIVISION
MIDDLE DIVISION
EASTERN DIVISION
OCTOBER 1945
NOVEMBER 1945
DECEMBER 1945
SCALE OF MILES
0 10 20 30 40 50 60

29th, temperatures dropped below freezing in many western counties, with a low reading of 22° on the latter date at Atwood and Oberlin, which is one of the lowest September readings on the State record.

The ground was too hard and dry for preparation of seed beds or sowing wheat over the eastern two-thirds of the State until rains began the latter part, and then it was generally too wet.

OCTOBER

The fall of moisture over Kansas this month was decidedly deficient, but over the eastern half there was an abundance of soil moisture due to heavy rains near the close of the previous month. In many parts of the western half the upper soil was becoming dry the close of the month.

The average precipitation over the eastern third was 0.97, inch; the middle third, 0.87 inch; the western third, 0.60 inch; and for the State as a whole, 0.81 inch, which was 1.14 inches below normal and less than half of the average for October one year previous.

Near normal temperatures and sunshine, the absence of heavy or prolonged rains, and several spells of Indian-summer weather made this a very pleasant month that was favorable for the maturing and harvesting of late crops.

It was a favorable month for sowing wheat, which work was practically completed, except in some southeastern counties, where it was delayed by wet soil.

NOVEMBER

This was a mild and sunshiny month but came very nearly being a record-breaker for dryness. Few places in the State received as much as half an inch of moisture and many western counties failed to get a measurable amount on any day. The average precipitation over the eastern third was 0.33 inch; the middle third, 0.06 inch; the western third, 0.06 inch; and for the State as a whole, 0.15 inch, which was 1.10 inches below normal, the least amount credited to November since 1921 and the fifth smallest November average since State-wide records were begun 58 years previous. Combined with the average for the dry October preceding, this made the fourth driest two-month period on record for this time of year.

The month was entirely too dry for wheat, which made only a slight growth and was furnishing little or no pasture. By the close the crop was almost at a standstill and the soil dried out to such an extent there was strong probability of winter killing. Farm work made excellent progress.

December

This month came very nearly being a record-breaker over Kansas for heavy snowfall and prolonged cold weather, with more cloudiness than usual. Over the eastern two-thirds of the State there was generally sufficient precipitation to relieve dry conditions that had prevailed through the two previous months but wheat in many western counties was still rather badly in need of more moisture at the close.

The average precipitation over the eastern third was 1.11 inches; the middle third, 0.88 inch; the western third 0.45 inch; and for the State as a whole, 0.81 inch, which was slightly below normal.

The average snowfall for the State was more than twice the usual amount. Many eastern and central counties had snowfall totalling 10 to 15 inches and these heavy snows extended as far west as Graham, Trego, and Ness Counties.

It was the sixth coldest December on record and the coldest month the State had experienced since January 1940. A low reading of 24° below zero on the 19th at Horton was, with two exceptions, the lowest ever recorded in the State during the month of December.

The outlook for wheat was materially improved over most of the eastern two-thirds but the crop continued to be in a precarious condition in many western counties. It was generally an unfavorable month for farm work.

Bloodroot (Sanguinaria canadensis) is among the earliest of our plants to brighten the Kansas woodlands with its attractive white and star-shaped blossoms—which is reason enough for its existence. But Indians in their day used the red latex exuded from its rhizomes (thick, bulb-like roots to uneducated chemists and geologists) to color themselves and their wares. At the present day, the alkaloid sanguinarine is extracted from the roots, being used for the relief of bronchitis. Photograph, courtesy Professor W. C. Stevens.

The Contribution of Kansas to *American Men of Science*, 7th Edition

H. E. ZABEL
Clay-Adams Company, New York City

The 7th edition of *American Men of Science,* the standard directory of the scientific profession, appeared during the war, a period when the policy of interrupting the production of scientists was adopted, and it is thus of special importance. The 7th edition (dated 1944) lists 34,114 names, an increase of 6,423 names over the 1938 edition. This increase maintains approximately the earlier rate in spite of an increasing death loss of 1645 scientists during the interim.

Place of Birth

The accompanying graph (Fig. 1) gives the place of birth of individual entries by states, arranged by totals for the 1944 edition. The entire section for the state represents the present total; the shadea section indicates the increase since 1938.

Kansas has a total of 828 native scientists, an increase of 118 since 1938. 156 new names are listed, of which 38 are required to replace losses (22 were lost by death). Only ten states have more native scientists than Kansas. However, California and Minnesota are rapidly overtaking Kansas, and with their larger population, will likely surpass her by the time the next edition of the directory is published.

If, as a basis for comparison, we select the census of 1900 as representing the date of birth, we find that Kansas ranks 24th in population but 11th in the number of scientists. Kansas has 528 scientists per million of population.* This proportion is surpassed by only six states: Utah, 1,065; Colorado, 657; Vermont, 589; Iowa, 580; Massachusetts, 568; and New Hampshire, 558.

We may similarly compute the proportion for Kansas in the previous edition (1938) when the median date of birth was about 1895. For every two million Kansans of the 1890 census plus the 1900 census, there were 490 native scientists in 1938. Kansas is increasing her number of scientists in proportion to her population.

The southern states and the north central states are the only other areas of the country where such an increase now occurs.

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*Note that this and subsequent values are minimum ones, for not all American scientists are listed in *American Men of Science*.

College Alumni

We may also classify scientists on the basis of the institution from which the individual was graduated with the A.B. degree or its equivalent (with no consideration of duplicate degrees). Kansas schools have 870 alumni scientists, 42 more than are native of the

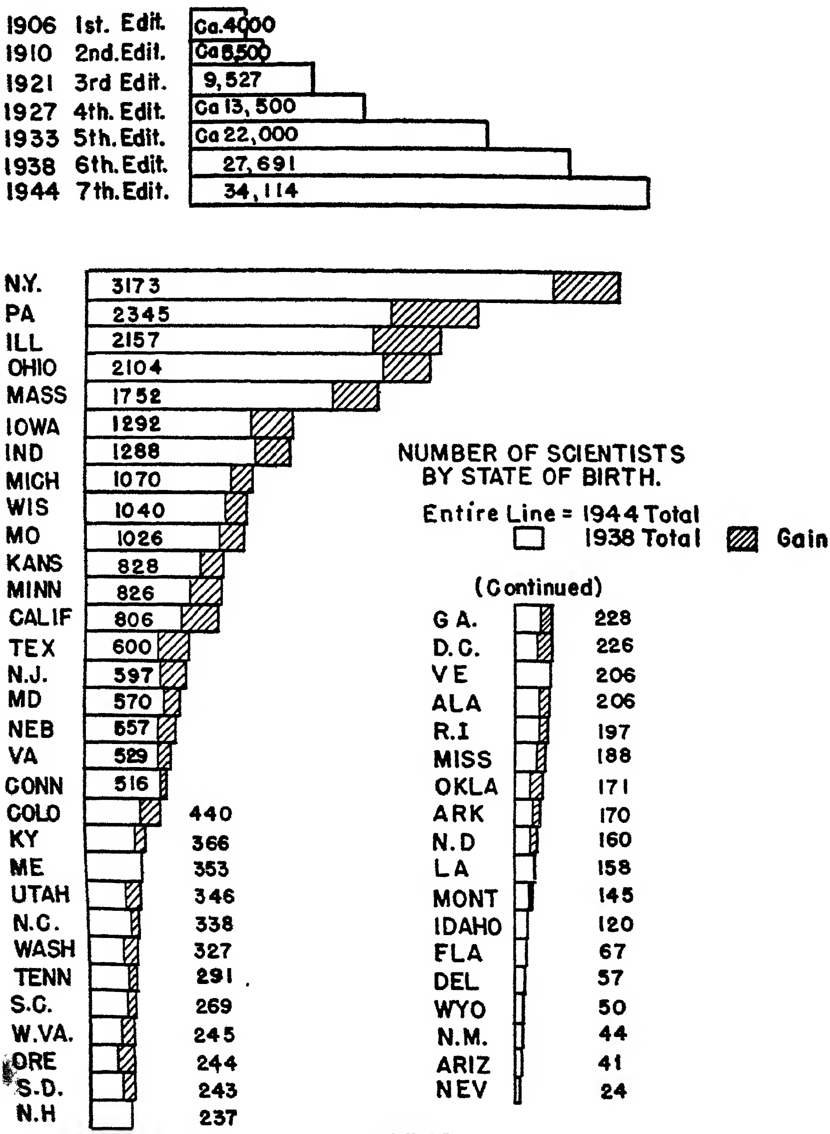

FIGURE 1.

state. A net balance of 42 scientists were attracted from outside Kansas to Kansas colleges and obtained their college degrees in the state.

In Figure 2, states are arranged according to the totals of their alumni scientists. The entire graph for each state indicates the totals; the shaded part of each graph indicates the amount of the increase since 1938. On this basis also, Kansas ranks 11th among the states.

Kansas, previous to 1938, had a very large number of college alumni scientists and while her alumni increased by 125, the rate of increase was less than the average. The number of college alumni scientists of the United States increased 23.5%. The rate of increase in Kansas over the very high previous total was 16.8%. Especially large rates of increase will be noted for Illinois, Ohio, California, Minnesota, Texas and Washington.

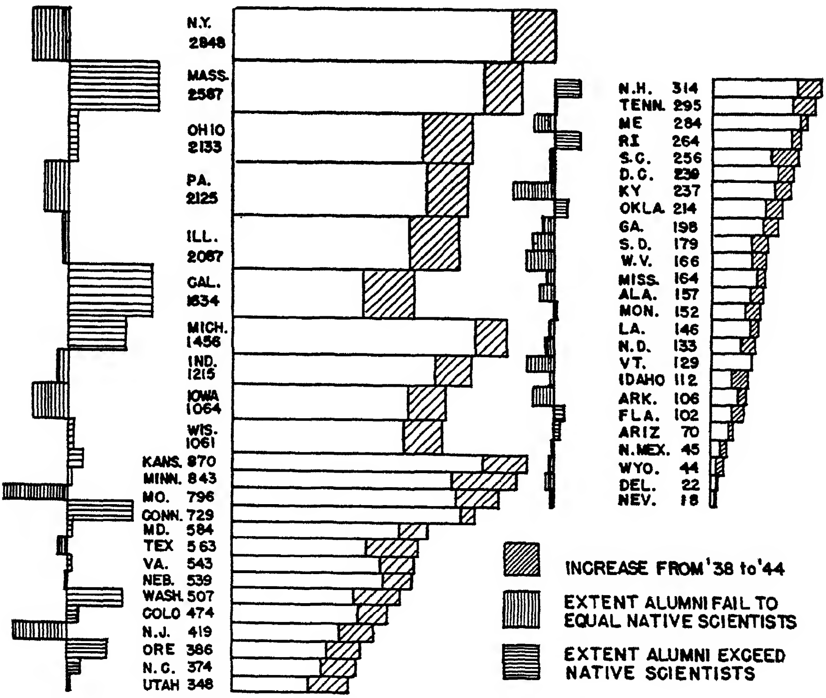

FIGURE 2.—ALUMNI SCIENTISTS BY STATES.

A supplementary graph to the left on Figure 2 compares the number of native scientists with the number of alumni scientists. The horizontal shading indicates the extent to which the alumni exceed

the native scientists. The vertical shading for a state indicates the excess of native scientists.

The graph shows that in 21 of the states there are more alumni scientists than native. Some are favored by a shift in population as California, Washington, Oregon, Oklahoma and Michigan. Some states have very large older endowed universities that draw a large proportion of their students from beyond the borders of the state in which they are located, e.g., M.I.T., Harvard, Yale, Dartmouth, Brown, and Johns Hopkins. Kansas is one of a number of states in which the colleges make a very good record without the benefit of the aavantages stated above. The showing of the Kansas colleges is even better than that of the native population. In most of the neighboring states the colleges are less productive than the native population, as we see for Missouri, Iowa, Arkansas and Nebraska.

The same is true for the entire North Atlantic region of New York, New Jersey and Pennsylvania. This region depends upon other regions for undergraduate training for an appreciable portion of its native scientists.

Universities and Colleges

If we arrange the larger universities and colleges of the United States according to the totals of the scientists among their alumni, the University of Kansas stands 18th, with 345, and Kansas State comes 26th with 250. In the past six years, the University of Kansas has surpassed Missouri and Indiana, but has, in turn, been passed by Penn State and by Iowa State and thus has retained the same rank. Although the order was different in 1944 than in 1938, the same 27 institutions head the list.

Alumni Scientists of the Larger Universities and Colleges

Cornell	866	M. I. T.	597	Missouri	334
Michigan	849	Columbia	515	Indiana	331
Calif.	767	Yale	497	Wash. (Seattle)	329
U.C.L.A.	67—834	Stanford	410	Johns Hopkins	307
Wisconsin	832	Penn. State	391	C.C. of N.Y.	306
Harvard	822	Penn.	384	Iowa	273
Illinois	786	Nebraska	364	Purdue	253
Chicago	661	Iowa State	348	Kansas State	250
Ohio State	640	Kansas	345	Mich. State	241
Minnesota	613				

The accompanying graph (Fig. 3) gives the distribution of the 870 Kansas alumni scientists by schools. It also indicates the increases that occurred since the 6th edition and shows the number of starred scientists among the alumni for each.

Southwestern (40), Baker (35), and Washburn (26), have been very productive. A number of alumni have assumed that their school is *the* state teachers college. To avoid any difference of opinion on

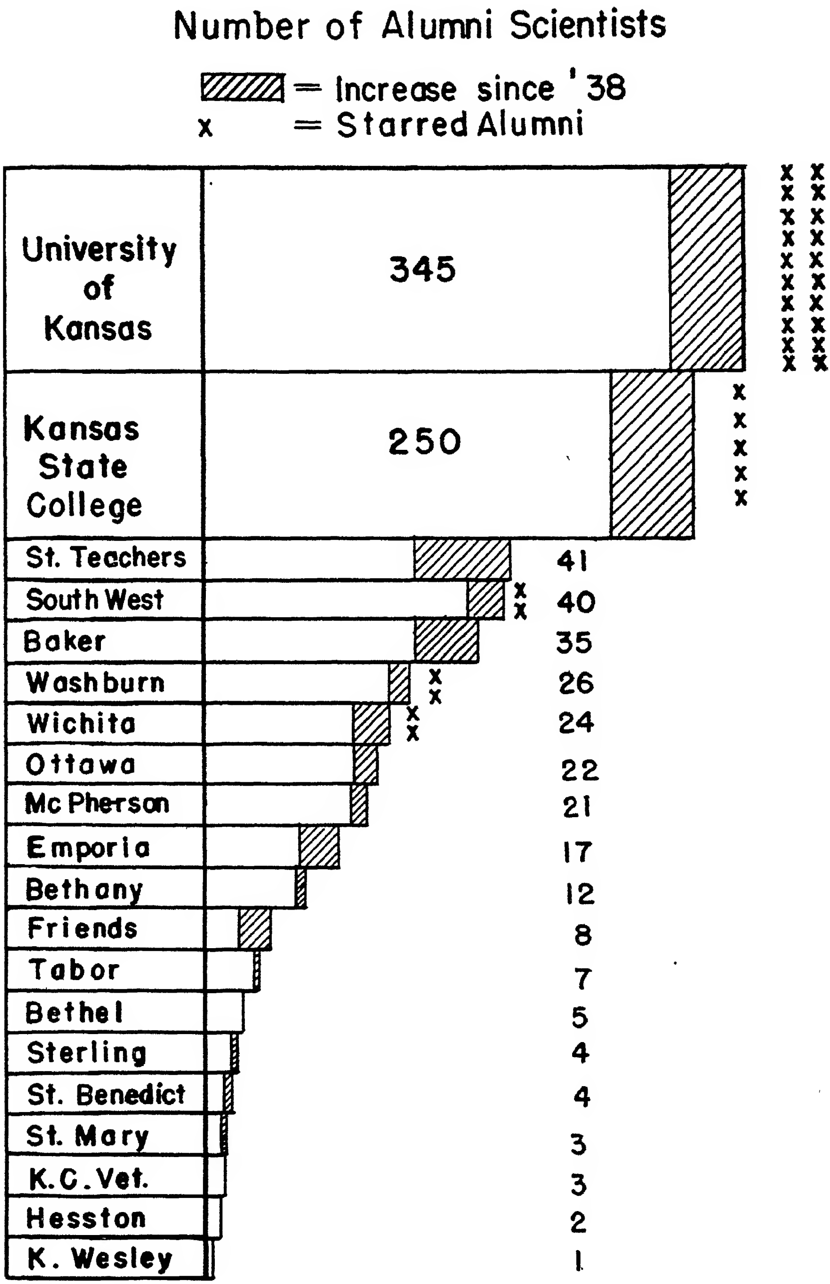
Number of Alumni Scientists
= Increase since '38
x = Starred Alumni
University of Kansas
345
Kansas State College
250
St. Teachers
41
South West
40
Baker
35
Washburn
26
Wichita
24
Ottawa
22
Mc Pherson
21
Emporia
17
Bethany
12
Friends
8
Tabor
7
Bethel
5
Sterling
4
St. Benedict
4
St. Mary
3
K.C. Vet.
3
Hesston
2
K. Wesley
1

FIGURE 3.

this matter the totals for the three schools have been combined. These schools, as well as Baker, Wichita, Emporia, and Friends, have had a large percentage of increase. The * indicates a starred alumnus.

Fields of Science

Figure 4 gives a classification of Kansas scientists according to the fields which they give as their specialty. There is some variation in the terminology used by scientists in naming their field. We have simplified this situation in a few cases to obtain the classifications listed below. Where two or more fields are claimed, only the first one given is used.

The first column, after the column stating the classification, tabulates the number of "native scientists," i.e. those born in the state; the second tabulates the number of alumni; the third tabulates only those having a final advanced degree (beyond an A.B.) from a Kansas school; the fourth column lists the temporary Kansas scientists; that is, other scientists who have lived and worked in Kansas at some time.

As will be seen, there is a close correspondence in the various sciences between the totals for the native and those for the alumni scientists.

The data given in this table invite a dramatization of their story. The first column represents the material our colleges and universities had to work with. As we have seen, it is of the best, the finest, in the country. The second column shows how well our undergraduate colleges have succeeded in the development of scientists with this material. The results are given for each science.

To take physicists, for example, Kansas produced 61 physicists, but Kansas undergraduate colleges can claim credit for only 47; other states have given Kansas students inspiration and guidance in becoming physicists. We note that at least three of these physicists with out-state training have become outstanding scientists. Five native physicists were starred but only two Kansas alumni were starred.

The last column represents the present Kansas scientists who are nearly all connected with our schools. It is to them that credit (or censure) accrues for the quality of the students. It should be remembered, however, that the 26 physicists now in Kansas can say, "The 26 temporary physicists listed in column four, who had our jobs before us, must share the responsibility for our successes and failures."

	Native	AB.Alum.	Advanced	Temporary	Now
CHEMISTRY	175 xxx xxx	171 xxx xxx	50	75 x x	36 x
AGRICULTURE	53	59	23	39	23
ENGINEERING	64	61	16	43	29
PHYSICS	61 xxx xx	47 xx	15	26 x	26 x
MATHEMATICS	38 x	37 x	6	28 xx xx	26 x
GEOLOGY	32 xxx	25 xx xx	6	29 xx	25 x
PSYCHOLOGY	41	53	4	37 xxx xx	25
ZOOLOGY	56 xxx xxx	68 xxx xxx	12	35 xxx xxx	26 xx
ENTOMOLOGY	48 x	60 x	29	18	16
BOTANY	33 x	30 xxx	8	28 xx	18
ANATOMY	20 xxx	24 xxxx	8	5 xx	6
PHYSIOLOGY	18 xxx	22 xxx	5	9	8
PATHOLOGY	7	11	6	1	6
BACTERIOLOGY	25 x	25	11	8 x	10
MEDIC. MISC'L	26	23	3	14	6
VET. MISC'L	9	13	7	3	2
GENETICS	11 x	10 x	2	6	2
BIOLOGY	17	17	5	13	7
HORT.	13	18	2	3	6
PLANT PATH.	20	13	3	10	6
FORESTRY	7	3	-	1	-
PHARM.	9	11	4	2	4
SOIL	11	10	2	3	3
NUTRITION	10 x	13 x	-	7	5
H. ECONOMICS	3	4	-	4	1
ASTRON.	5 x	5 x	-	6 x	2
METEOROLOGY	1	1	1	-	-
ARCHEOLOGY	3	-	-	-	-
GEOGRAPHY	3	-	2	-	1
STATISTICS	1	3	-	1	2
ANTHROPOLOGY	4	1	-	2	2
ECONOMICS	6	6	1	7	3
			230	463	351

FIGURE 4.—KANSAS SCIENTISTS.

The comparison of the native and alumni columns gives a uniformly fine showing for the colleges. The instances where there is a deficit in the alumni column usually amount to a difference of only a few scientists, while the favorable balance in psychology, zoology, and entomology is quite considerable. The totals for chemistry look

out of proportion at first sight. But they are in line with results observable in other midwest states. Iowa has produced nearly twice as many chemists as Kansas.

States with large municipalities have aggravated medical problems and tend to put special emphasis on the medical sciences. Kansas scientists include a goodly number of anatomists, bacteriologists and other medical scientists. Kansas is one of the eight states that have schools of veterinary science.

In the graduate schools of Kansas, as seen from the 230 scientists listed in column three, the number of advanced students as compared to the native scientists is particularly high in the fields of chemistry, entomology, agriculture, engineering and physics. To a lesser extent, the number of graduate zoologists and bacteriologists is high when compared to native scientists in these fields.

Kansas graduate schools are becoming self sufficient in the sense that the number of scientists to whom they have given their final degrees approaches the number of scientists within the state. We may note that some neighboring states, including Illinois, Minnesota, and Iowa have more scientists with advanced degrees than native or alumni scientists.

The last column gives the total of 351 scientists now in Kansas. The proportion of present Kansas scientists in the various scientific fields is approximately the same as the proportion that exists on a national scale. This result is in part due to the fact that the 351 scientists are nearly all in schools and experimental departments. A comparatively large number lies in the fields that have been noted as most productive. None claims archeology or forestry and but one each specifies geography and home economics, two each anthropology, astronomy, statistics, and genetics as their main field.

Approximately one-fourth of the present Kansas scientists (84) are both natives of the state and alumni of her colleges. 44 have come from other states, have become alumni and stayed on. The "labor turnover" has been small. Only 515 scientists besides her alumni and native scientists may be called "former Kansas scientists."

Institutional Connections

The foregoing totals include a number of duplicates. Figure 5. on the institutional connections of Kansas scientists, omits all duplicates.

Teaching and research in colleges and universities is the traditional field of work for American scientists and we find the largest

	INDUSTRY	UNIV. COL'GE EX.STA.	GOV'T	F'ND'NS MUSEUM	PRIVATE CONS'LT'G	MISC. & RETIRED	
CHEMISTRY	99	109	25	8	3		
PHYSICAL	15	13	8	1	2		
ORGANIC	21	25	1	1	-		
BIOCHEMICAL	4	17	4				
PHYSIOLOGICAL	2	1					
METALLURGICAL	5	2		1			
CEREAL	2	2					
PHYSIOLOGY	2	36	1		1	1	
AGRICULTURE	5	87	36		1	3	
PHYSICS	20	80	18	5			
GEOLOGY	29	32	14	1	5	2	
PSYCHOLOGY	7	101	3	-	6	2	
SPEECH	-	3					
ZOOLOGY	2	96	7	6	1	2	
ENTOMOLOGY	1	56	39	4	2		
PARASITOLOGY		9	3	1			
ECOLOGY		7	1	1			
BOTANY	2	52	10		1	2	
PLANT PHYSIOL.	2	10	5	1			
PLANT PATH.	4	21	12				
HORTICULTURE		20	5			1	
FORESTRY		4	5				
ANATOMY		37		2	1		
PHARMACOLOGY	1	15		1			
PATHOLOGY	3	16	1	1			
BACTERIOLOGY	8	28	8	3	1		
MED. MISC'L.	5	33	7	1	6	2	
VET. MISC'L.		16	5				
GENETICS	2	17	6	1	1		
SOILS	2	9	8				
NUTRITION	1	15	1	1	1		
HOME ECONOMICS		8	1				
EDUCATION		3					
ASTRONOMY		7	1	5			
METEOROLOGY				1	1		
ARCHEOLOGY		2	1				
GEOGRAPHY		5	1				
STATISTICS		3	2				
ANTHROPOLOGY		2	1	2		1	
AGRI. ECONOMICS	1	6	12				
BIOLOGY	1	29	7	2	1		
PALEONTOLOGY	1	8	1	5			
MATHEMATICS		95	2			1	
ENGINEERING	25	104	14	2	7	3	
	272	1241	276	57	41	20	1907

FIGURE 5.—INSTITUTIONAL CONNECTIONS, KANSAS SCIENTISTS.

group here. This is markedly true in engineering, agriculture, horticulture, nutrition, and most of the basic sciences: mathematics, zoology, botany, psychology, anatomy and physiology.

Remarkable is the very large number (276) of Kansas scientists that are in government service—actually more than have gone into industrial work. It approaches the total number of scientists now in the state. The government has drawn quite uniformly on all branches of science, and has taken a full dozen of Kansas agricultural economists. We will not hold Kansas responsible for New Deal "planned economy" but Kansas has contributed appreciably to the strength of the central government. Large contributions are made in entomology, soils, and miscellaneous agricultural fields.

Relatively few Kansas scientists have gone into industry. Most scientists with commercial firms are chemists, which include nearly half of the organic and physical chemists. Other large groups are the geologists, physicists and bacteriologists. 188 commercial firms are beneficiaries of this group of 272 scientists. Many lines of business are represented. The following groups indicate how widely they reach into our industrial life:

duPont	17
Standard Oil Companies	11
Bell Telephone	10
Phillips Petroleum	7
Bakelite	6
Eastman Kodak	5
U. S. Rubber	5
Aluminum Co. of America	4
American Cyanamid Co.	4
Procter and Gamble	3
R. C. A. Corporation	3
Magnolia Petroleum Co.	3
Dow Chemical	3
Libby-Owens Ford Glass Co.	3

A select group of able Kansas scientists has gone to foundations, research institutes, and museums, among whom are

Mellon Institute	7
Carnegie Institution	7
Rockefeller Foundation	3
Rockefeller Institute	3
Armour Research Foundation	3

An appreciable group is connected with museums including

U. S. National Museum	7
American Museum of Natural History	4

Private investigators and consulting scientists include, among others, geologists, engineers, psychologists, and chemists.

Starred Scientists

We have previously compared Kansas scientists on the basis of native and of alumni scientists. In nationally and internationally recognized scientists, Kansas has an even better record. Of the 255 scientists starred for the first time in the 7th edition (197 native of the U. S.), 10 are native Kansans. Only seven states have more. The west north central states made the outstanding contribution of 39 newly starred scientists; Kansas leads (the west north central states) with 10, more than making up for a weaker showing in the 6th edition (Fig. 6).

More of the recently starred scientists are native of the north central states than of all the rest of the states combined, 102 out of 197. Of the starred scientists still living of the 3rd, 4th and 5th groups, the north central states have furnished nearly half:

3rd group	1921	North Central States	108	out of	224
4th group	1927	North Central States	83	out of	178
5th group	1933	North Central States	91	out of	191
7th group	1944	North Central States	102	out of	197

The north central states are definitely leading the nation in the production of our outstanding scientists.

Of the starred scientists in the 7th edition, 32 are native Kansans:

(6) Zoology: H. W. Beams and E. E. Carothers, Iowa; G. F. Ferris, Stanford; S. F. Light, California; D. E. Minnich, Minn.; D. H. Wenrich, Penn.

(6) Chemistry: L. O. Brockway, Mich.; V. K. LaMer, Columbia; W. M. Latimer, Calif.; W. H. Rodebush, Ill.; E. R. Weidlein, Mellon Institute; L. H. Adams, Carnegie Institution.

(5) Physics: S. J. Barnett, Calif. at L. A.; J. W. Beams, Va.; H. V. Neher and J. D. Strong, Cal. Tech.; F. R. Watson, Ill.

(3) Anatomy: S. R. Guild, Hopkins; C. H. Heuser, Carnegie Institute; G. H. Scott, So. Calif.

(3) Geology: E. L. DeGolyer, petroleum geologist; C. O. Dunbar, Yale; H. E. Merwin, Carnegie Institute.

(2) Physiology: D. B. Dill, Harvard; W. J. Meek, Wisc.

Astronomy: P. Fox, Harvard.

Botany: P. C. Mangelsdorf, Harvard.

Mathematics: L. M. Graves, Chicago.

Genetics: D. F. Jones, Conn. Exp. Station.

Nutrition: E. V. McCollum, Hopkins.

Entomology: C. L. Marlatt, Dept. of Agr., retired.

Bacteriology: C. TenBroeck, Rockefeller Institute.

Nineteen of the above starred scientists are also alumni of Kansas colleges. In addition,* Kansas alumni include for the University of Kansas: E. C. Case, Michigan; C. T. Elvey, astronomer of Chicago-Texas Observatory; C. E. McClung, Penn.; A. F. Rogers, Stanford; E. H. Sellards, Texas; W. W. Swingle, Princeton; R. E.

*Note that while the list that follows includes Kansas alumni, the individuals listed are not *native* Kansans.

								Total
ME	4	5	3	1	2	2	1	18
N.H.	3	1	3	2	-	-	3	12
VT.	3	1	3	2	2	-	1	12
MASS	26	13	22	16	17	13	11	119
RI	1	3	-	1	1	-	-	6
CONN	10	4	6	4	4	4	3	34
N.ENG.	47	27	37	26	26	19	19	201
NY.	36	16	26	20	29	17	16	160
NJ.	9	1	4	3	3	7	2	29
PA.	13	8	16	16	11	21	14	99
N.ATL.	58	25	46	39	43	45	32	288
OHIO	25	11	25	12	14	13	16	116
MICH	9	10	6	4	4	8	8	49
IND	11	9	12	4	9	5	11	61
ILL	16	6	14	18	21	11	23	109
WIS	16	7	10	13	5	2	4	57
EN. CENT	77	43	67	51	53	39	62	392
MINN	1	2	6	6	7	5	7	34
IOWA	9	8	18	6	7	6	6	60
MO	8	4	9	10	9	9	5	54
N.D.	-	-	-	1	-	-	2	3
S.D.	-	-	1	2	2	2	2	9
NEB	2	-	4	2	5	2	7	22
KANS	2	1	3	5	8	3	10	32
W.N.CENT	22	15	41	32	38	27	39	214
S.ATL.	16	12	17	18	9	15	12	99
E.S.C.	4	3	5	5	3	5	4	29
W.S.C	2	2	2	1	3	3	4	17
MTS.	1	-	1	5	7	6	5	25
COAST	6	4	8	1	9	14	16	58
U.S.A.	233	131	224	178	191	173	193	1323
N.CENT	99	58	108	83	91	66	101	606

FIGURE 6.—STARRED SCIENTISTS BY STATE OF BIRTH.

Scammon, Minnesota; F. A. Hartman, Ohio State; C. A. Kraus, Brown; F. A. Wetmore, U. S. National Museum; C. G. Croneis, Chicago. For Kansas State College: W. T. Swingle, Dept. of Agriculture; David Fairchild, retired. For Southwestern College: J. L. Oncley, Harvard Medical College. (Professor Gordon Scott, already listed above is also an alumnus of Southwestern. For Wichita, H. W. and J. W. Beams, and for Washburn, L. M. Graves, Chicago, and S. R. Guild, Hopkins, have also been listed above.)

In addition to the foregoing starred scientists, 26 former scientists of Kansas have been starred.

6 in Zoology: W. E. Castle, California; C. L. Turner, Northwestern; L. R. Dice and P. S. Welch, Michigan; F. L. Hisaw, Harvard; A. A. Schaeffer, Temple.
5 Psychology: J. P. Guilford, So. Calif.; R. M. Ogden, Cornell; W. S. Hunter, Brown; D. G. Paterson, Minnesota; R. S. Woodworth, Columbia, retired.
4 Mathematics: S. Lefschetz, Princeton; A. Emch and G. A. Miller, Illinois; E. J. McShane, Virginia.
2 Botany: N. E. Stevens, Illinois; C. A. Shull, Chicago.
2 Chemistry: E. Bartow, Iowa; S. B. Hendricks, Dept. of Agric.
1 Geology: W. H. Twenhofel, Wisconsin.
1 Neurology: C. Judson Herrick, Chicago, retired.
1 Physics: O. M. Stewart, Mo., retired.
1 Astrophysics: E. Pettit, Mt. Wilson Observatory
1 Embryology: B. M. Allen, California at L. A.
1 Parasitology: L. R. Cleveland, Harvard.

The resident starred scientists of Kansas institutions are Professors Ackert and Nabours of Kansas State College, and Professors Dains, Kester, Moore and Stouffer of the University of Kansas. These institutions have had the services of all these outstanding scientists since 1916.

Concluding Observations

In the future, the welfare of our country will be dependent less upon our natural resources and more upon the work of our scientists. Yet we have interrupted the specific training of our future scientists drastically as other warring nations have not done. Many of our early scientists who helped attain a leading place for American scientists are leaving the field of activity.

Several of the states that were among the early leaders in the production of scientists are now doing little more than replacing their losses. In the face of much keener competition they have not been able to maintain their number of outstanding scientists.

An increasing proportion of our scientists are coming from the families of scientists. Most of Kansas alumni scientists leave the state. In this way they will furnish scientists credited to other states rather than to Kansas.

It will take liberal support of our colleges and universities in our science departments and of our scientists to maintain our fine record and especially to improve it.

A Report on Some Amphibians and Reptiles From Louisiana

CHARLES E. BURT
Quivira Specialties Company, Topeka

Most of the records given here are the result of personal field work with special reference to 1935 and 1936 plus a survey of the records of the United States National Museum. The early part of the collecting was co-operatively supported by a grant from the Smithsonian Institution through the kindness of Dr. Alexander Wetmore and the late Dr. Leonhard Stejneger for whom many turtles now in the National Museum (but not reported here) were obtained. Appreciated field assistance was given by Mr. Harry Viosca of New Orleans, Louisiana, on a trip through St. Tammany Parish on July 30, 1936.

Salamanders

Amphiuma means tridactylum (Cuvier)

The Congo "eel" was secured at Morgan City, St. Mary Parish, by Arthur and Ruth D. Svihla, in 1925.

Triturus viridescens louisianensis (Wolterstorff)

Newts were found in a marshy woodland 4 miles S.W. of Ferriday, Concordia Parish, on August 3, 1936.

Ambystoma opacum (Gravenhorst)

Marbled salamanders were taken near a pond in woodland at Bush, St. Tammany Parish, on July 30, 1936. The U. S. National Museum has specimens from the same parish from Covington (Percy Viosca, Jr., Mar. 12, 1923) and Madisonville (May 29, 1886).

Ambystoma talpoideum (Holbrook)

Three of these uncommon salamanders were sent to me by Harry Viosca on April 15, 1939 and were collected at Greensburg, St. Helena Parish. Lichenous white markings made a stippled pattern on the liver-black body, tending toward the formation of crossbars on the tail.

Desmognathus fuscus auriculatus (Holbrook)

Dusky salamanders were taken on July 30, 1936, at Bush, St. Tammany Parish; and also 9 miles E. of Franklinton, Washington Parish, near the edge of woodland ponds and streamlets.

Plethodon glutinosus glutinosus (Green)

Slimy salamanders were found under rotted logs in woods near a pond at Bush, St. Tammany Parish, on July 30, 1936.

Eurycea longicauda guttolineata (Holbrook)

U. S. National Museum records: Clinton, E. Feliciana Parish, June 4, 1888 (G. Kohn); Covington, St. Tammany Parish, Aug. 24, 1915 (Percy Viosca).

Toads

Microhyla carolinensis (Holbrook)

Narrow-mouth toads were secured as follows: 4 miles S.W. of Ferriday, Concordia Parish, Aug. 3, 1936; 5 miles N. of Mamou, Evangeline Parish, June 8, 1935; 2 miles S. of Meeker, Rapides Parish, June 8, 1935; at Luling, St. Charles Parish, June 7, 1935; and at Franklinton, Washington Parish, July 30, 1936.

Scaphiopus holbrookii holbrookii (Harlan)

Spadefoot toads were taken in marshy woodland near Mandeville, St. Tammany Parish, July 30, 1936.

Bufo quercicus Holbrook

On July 30, 1936, oak toads were found in St. Tammany Parish, 12 miles S.E. Mandeville and 5 miles S. of Slidell; and in Washington Parish at Franklinton, near streamlets and ponds in the woods.

Bufo terrestris (Bonnaterre)

Southern toads were located near swamps 5 miles S. of Lecompte, Rapides Parish, June 8, 1935; and at Bush, St. Tammany Parish, July 30, 1936.

Bufo valliceps Wiegmann

On June 8, 1935, these toads were secured near ponds 3 miles N. of Meridian, Evangeline Parish; and 5 miles S. Lecompte, Rapides Parish.

Bufo woodhousii fowleri Hinckley

These toads were taken at the edge of a marsh near a woods 4 miles S.W. of Ferriday, Concordia Parish, on August 3, 1936.

Frogs

Acris gryllus (Le Conte)

Cricket frogs are abundant at the margin of most ponds and streams in Louisiana. Records are: 4 miles S.W. of Ferriday, Con-

cordia Parish, August 3, 1936; 1 mile N. of Meridian, Evangeline Parish, June 8, 1935; 20 miles S.E. of Houma, Lafourche Parish, July 23, 1936; Rilla, Ouachita Parish, June 9, 1935; Morgan City, St. Mary Parish, 1925 (Arthur Svihla); 12 miles S.E. of Mandeville, Pearl River, and 5 miles S. of Slidell, in St. Tammany Parish, July 30, 1936; and Franklinton, Washington Parish, July 30, 1936.

Hyla avivoca Viosca

This treefrog was taken near a woodland pond at Bush, St. Tammany Parish, on July 30, 1936.

Hyla cinerea cinerea (Schneider)

The records of Bell's frogs are: 6 miles W. of Shreveport, Caddo Parish, June 10, 1935; 5 miles N. of Mamou and 1 mile N. of Meridian, Evangeline Parish, June 8, 1935; 20 miles N.E. of Houma, Lafourche Parish, July 23, 1936; 5 miles S. of Lecompte and 2 miles S. of Meeker, Rapides Parish, June 8, 1935; Morgan City, St. Mary Parish, (Arthur Svihla), 1925; and 5 miles S. of Slidell, St. Tammany Parish, July 30, 1936.

Hyla femoralis Latreille

On July 30, 1936, these treefrogs were taken in St. Tammany Parish near ponds 12 miles S.E. of Mandeville and 5 miles S. of Slidell.

Hyla gratiosa Le Conte

On July 30, 1936, barking frogs were found in marshy woodland at Mandeville and at Pearl River, St. Tammany Parish.

Hyla squirella Latreille

The records are: Grand Isle, Jefferson Parish, July 4, 1938; Morgan City, St. Mary Parish, 1925 (Arthur Svihla); 12 miles S.E. of Mandeville and 5 miles S. of Slidell, St. Tammany Parish, July 30, 1936; Perry, Vermilion Parish, June 20, 1904 (A. Allison).

Hyla versicolor Le Conte

Recorded as follows: 5 miles N. of Mamou and 1 mile N. of Meridian, Evangeline Parish, June 8, 1935; 20 miles N.E. of Houma, Lafourche Parish, July 23, 1936; 5 miles S. of Lecompte and 2 miles S. of Meeker, Rapides Parish, June 8, 1935; Morgan City, St. Mary Parish, 1925 (Arthur Svihla); Bush and Mandeville, St. Tammany Parish, July 30, 1936.

Rana catesbeiana Shaw

Bullfrogs were found 6 miles N.W. of Kenner, Jefferson Par-

ish, June 8, 1935; Ruddock, St. John the Baptist Parish, June 8, 1935; 10 miles S.E. of Morgan City, St. Mary Parish, June 7, 1935; near Bush and 5 miles S. of Slidell, St. Tammany Parish, July 30, 1936; Perry, Vermilion Parish, June 20, 1904 (A. Allison).

Rana clamitans Latreille

Young green frogs 22 to 30 mm. long with four legs were secured on August 3, 1936, 4 miles S.W. of Ferriday, Concordia Parish; older specimens were taken in marshy woodland 3 miles N. of Meridian, Evangeline Parish, June 8, 1935; 6 miles N.W. of Kenner, Jefferson Parish, June 8, 1935; 20 miles N.E. of Houma, Lafourche Parish, July 23, 1936; 5 miles S. of Lecompte, Rapides Parish, June 8, 1935; 10 miles S.E. of Morgan City, St. Mary Parish, June 7, 1935; Bush, Mandeville, 12 miles S.E. of Mandeville, and 5 miles S. of Slidell, St. Tammany Parish, July 30, 1936; Perry, Vermilion Parish, June 20, 1904 (A. Allison); 9 miles E. of Franklinton, Washington Parish, July 30, 1936.

Rana grylio Stejneger

Lesser bullfrogs were taken 5 miles S. of Slidell, St. Tammany Parish, July 30, 1936, near a streamlet in the woods.

Rana pipiens Schreber

Leopard frogs were secured 2 miles S. of Selma, Grant Parish, on June 9, 1935, at a pond in cut over pine barrens; 2 miles N. of Rilla, Ouachita Parish, June 9, 1935; Pearl River and 5 miles S. of Slidell, St. Tammany Parish, July 30, 1936.

Turtles

Pseudemys troosti elegans (Wied)

On Aug. 3, 1936, green slider terrapins were found in a shallow roadside ditch 4 miles S.W. of Ferriday, Concordia Parish. On September 15, 1942, I received from a dealer at White Castle, Iberville Parish, Siamese twins of this species. The two turtles had separate tails but were united ventrally (face to face) from the base of the tails to the umbilical area. The plastrons were equal in size, 32 mm. long, joined for 18 mm.; the carapace was slightly asymmetrical in each case. The anterior parts appeared to be normal.

Alligators

Alligator mississippiensis (Daudin)

Baby alligators have been obtained from Bellerose, Assumption Parish, Aug. 20. 1943; Bayou Gross Tete near Gross Tete, Iberville

Parish, June 15, 1935; and at Houma, Terrebonne Parish, June 16, 1935.

Lizards

Anolis carolinensis Voigt

Chameleons are found on bushes at the edge of bayous and other marshy areas. I have repeatedly observed them around tourists camps in New Orleans, Orleans Parish; specimens were taken 4 miles S.W. of Ferriday, Concordia Parish, August 3, 1936; 20 miles N.E. of Houma, Lafourche Parish, July 23, 1936; and 10 miles S.E. of Morgan City, St. Mary Parish, June 7, 1935.

Sceloporus undulatus undulatus (Latreille)

Fence lizards were found in cut over pine barrens 2 miles S. of Selma, Grant Parish, June 9, 1935; and in the woods 6 miles N.W. of Jena, La Salle Parish, Aug. 3, 1936; Bush and 5 miles S. of Slidell, St. Tammany Parish, July 30, 1936; 1 mile W. of Hammond, Tangipahoa Parish, June 8, 1935; and 9 miles E. of Franklinton, Washington Parish, July 30, 1936.

Leiolopisma unicolor (Harlan)

The brown-backed skink is obviously the most common and generally distributed lizard in Louisiana, but it occurs along the forest floor where cover is excellent and escape relatively easy. It was found 4 miles S.W. of Ferriday, Concordia Parish, Aug. 3, 1936; 5 miles N. of Mamou, Evangeline Parish, June 8, 1935; 2 miles S. of Selma, Grant Parish, June 9, 1935; 6 miles N.W. of Jena, La Salle Parish, Aug. 3, 1936; 5 miles S. of Slidell, St. Tammany Parish, July 30, 1936; 1 mile W. of Hammond, Tangipahoa Parish, June 8, 1935; and 9 miles E. of Franklinton, Washington Parish, July 30, 1936.

Eumeces fasciatus (Linnaeus)

Both young and older "red-headed or scorpion" phases of this skink were obtained from Henry St. Germain of Belle Rose, Assumption Parish, on April 1, 1942. Other records are 4 miles S.W. of Ferriday, Concordia Parish, Aug. 3, 1936; 20 miles S.E. of Houma, Lafourche Parish, July 23, 1936; 6 miles N.W. of Jena, La Salle Parish, Aug. 3, 1936; Bush and 5 miles S. of Slidell, St. Tammany Parish, July 30, 1936.

Snakes

Farancia abacura reinwardtii (Schlegel)

Horn snakes are common near bayous. Records are 1 mile S. of Rodessa, Caddo Parish, June 10, 1935; Riverton, Caldwell Par-

ish, June 9, 1935; 1 mile N. of Meridian, Evangeline Parish, June 8, 1935; 20 miles N.E. of Houma, Lafourche Parish, July 23, 1936; and Franklin, St. Mary Parish, June 7, 1935.

Diadophis punctatus strictogenys Cope

On July 30, 1936, a ring-neck snake was found in a rotted log near a pond at Bush, St. Tammany Parish.

Opheodrys aestivus (Linnaeus)

A rough green snake was taken at Segura, Iberia Parish, on June 7, 1935.

Coluber constrictor anthicus (Cope)

Disregarding their spots, the speckled blue racers listed here are color intergrades between the adjacent subspecies *constrictor* and *flaviventris.* They all show a greater or lesser amount of light spotting; the spots are light brown to light bluish white in life. One blackish specimen was almost devoid of light flecks. Records are Rochelle, Grant Co., June 9, 1936; 3 miles N. Riverton, June 9, 1936, and 1 mile N. of Tullos, La Salle Co., June 9, 1936.

Elaphe guttata (Linnaeus)

One corn snake was captured near Slidell, St. Tammany Parish, in 1935.

Elaphe obsoleta (Say)

On June 9, 1935, a pilot black snake was taken in the Kisttachie National Forest 4 miles N. of Grant, Allen Parish.

Lampropeltis getulus holbrooki (Stejneger)

Salt and pepper snakes were obtained 6 miles W. of Shreveport, Caddo Parish, June 10, 1935; 6 miles N.W. of Kenner, Jefferson Parish, June 8, 1935; and 10 miles S.E. of Morgan City, St. Mary Parish, June 7, 1935.

Natrix erythrogaster erythrogaster (Forster)

One red-bellied water snake was collected near a woodland pond margin at Bush, St. Tammany Parish, on July 30, 1936.

Natrix rhombifera rhombifera (Hallowell)

Diamond-back watersnakes were found 5 miles N. of Eunice, St. Landry Parish, on June 8, 1935.

Natrix sipedon confluens (Blanchard)

This watersnake was taken at Bush, St. Tammany Parish, July 30, 1936.

Natrix sipedon fasciata (Linnaeus)

One was captured 1 mile W. of Hammond, Tangipahoa Parish, June 8, 1935.

Storeria dekayi (Holbrook)

These wood snakes were secured at Bush, St. Tammany Parish, near a pond, July 30, 1936.

Thamnophis sauritus proximus (Say)

Reports from marshy woodland are: 4 miles S.W. of Ferriday, Concordia Parish, Aug. 3, 1936; 10 miles S.E. of Morgan City, St. Mary Parish, June 7, 1935.

Agkistrodon mokeson austrinus Gloyd and Conant

A copperhead was found 10 miles S.E. of Morgan City, St. Mary Parish, June 7, 1935.

Agkistrodon piscivorus leucostoma (Troost)

Cottonmouths were taken 1 mile N. of Frenier, St. John the Baptist Parish, June 8, 1935; 6 miles N.W. of Kenner, Jefferson Parish, June 8, 1935; 20 miles N.E. of Houma, Lafourche Parish, July 23, 1935.

Sistrurus miliarius streckeri Gloyd

In June 1935, a dwarf rattler was located at Michaud, Orleans Parish.

An Analysis of Scatter in Intelligence Test Results: A Review of the Literature*

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Clinical psychologists have long believed that the unevenness of attainment on different kinds of items in an intelligence test may be used to help recognize various mental illnesses. For almost 35 years attempts have been made to discover the relation between mental illness and such qualitative features of intelligence test results. Only within the past ten years have these attempts met with a measure of success. Diagnostic intelligence testing is now an indispensable tool of many clinical psychologists. In this review we shall trace the history of the use of scatter in intelligence and achievement test results.

Scatter may be defined as unevenness in the level of attainment on different tests. For example, scatter is seen in a test like the Stanford-Binet in the subject's failing an item on a given mental age level, while he passes other items on higher mental age levels; or it can be seen in the comparison of the score obtained by a subject on a reading achievement test with the score obtained on an arithmetic achievement test.

We shall treat in this review (1) scatter on the Stanford-Binet Intelligence Test, (2) scatter in inter-test comparisons, (3) scatter on the Wechsler-Bellevue Intelligence Scale. Publications dealt with in previous reviews of the literature will be treated only through these reviews and will be omitted from our bibliography. For these references, the bibliographies of the publications listed under "Bibliographical Sources" may be consulted.

1. Scatter on the Stanford-Binet Intelligence Test.

In this section we shall consider the significance on the Stanford-Binet of: (a) amount of scatter, (b) selective scatter, and (c) psychological rationale of scatter.

(a) *Amount of Scatter* Amount of scatter refers to the general unevenness in the distribution of successes and failures, and is measured by various numerical measures of scatter. In their

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review of the literature up to 1937, Harris and Shakow [18] summarized nine measures of scatter which had been used. These were of three main kinds:

1. Range of scatter: number of age levels from the basal level to the level where all items are failed.
2. Area of scatter: the number of items passed above and failed below the mental age level.
3. Range and area of scatter: weighting of the number of successes and failures on each level by the distance of that level from the mental age; e.g., Pressey multiplied failures below and passes above the mental age by the number of year levels separating each test from the mental age.

Harris and Shakow pointed out the frequent occurrence of contradictory findings and discussed the reasons for these contradictions and the limitations of each of these measures.[18, 19] They concluded that "Research up to now has failed to demonstrate clearly any valid clinical use for numerical measures of scatter". Nevertheless, they state that given a scatter rating above certain critical limits, "the existence of pathology might be considered probable".[19 p. 108] No data were, however, presented by which this conclusion could be evaluated.

In 1938, Malamud and Palmer [30] compared the performance of a group with organic pathology, a group of schizophrenics, and a group with subnormal intelligence, all three equated for mental age. The schizophrenics and organics had significantly greater scatter than the subnormals according to all three kinds of measures described above. All these scatter measures correlated positively with each other and with the measure of the discrepancy between vocabulary mental age and Stanford-Binet mental age.

In 1940, Kendig and Richmond [23] found that, with mental age held constant, the average scatter of their dementia praecox group was greater than that of their mental defectives or normal controls; "but hardly sufficiently higher to be clinically significant".[23 p. 80] They too stated that in individual cases of dementia praecox the scatter may be unusually great, but they present no data to establish the significance of this observation.

Brody in 1942 [11] indicated that the critical limits set by Harris and Shakow for significance of a scatter score on the 1916 revision of the test were too low for the 1937 revision, and that his results were too uncertain to justify the selection of new critical levels. Trapp and James,[47] and Worchel [53] found no significant change in

amount of scatter in tests of schizophrenics upon either greater deterioration or recovery respectively.

In 1944, Hunt and Cofer [20 p. 984] presented a brief review of the literature and concluded that "the scatter approach appears now to be a blind alley".

Summary: Numerical measures of scatter on the Stanford-Binet have proved to be virtually useless as aids in clinical diagnosis; nevertheless, the impression has persisted among clinical psychologists that the extent of scatter on the Stanford-Binet may be indicative of maladjustment.

(b) *Selective Scatter.* A more meaningful approach to the analysis of scatter was the search for "selective scatter", i.e., the attempt to determine the effects of specific psychiatric disorders on the ability to pass specific kinds of items. The significant studies are reviewed by Kendig and Richmond,[23] Roe and Shakow,[42] and Brody.[10]* More recent pertinent studies are those of Piotrowski,[32] Roe and Shakow,[42] and Meyers and Gifford.[31]

These studies dealt mainly with schizophrenics. There is some agreement in their findings to the effect that schizophrenics appear to be less proficient than normals or non-psychotic patients on the following items: detecting absurdities, interpretation of fables, ball and field test, memory for designs, and problem questions; they appear to be more proficient in arithmetical reasoning. With respect to none of these items, however, is there unanimous agreement. Some contradictory findings are reported; several studies indicate that schizophrenics are worse than normals in repetition of digits, vocabulary, finding differences between abstract words, and making inductions, while others report the reverse. Finally, on more than fifteen other items schizophrenics seemed to show significant impairments in one or two studies but not in others. The reasons which have been offered for this essential lack of agreement are: (1) use of inadequate control groups; (2) no control of mental age; (3) no control of chronological age; (4) no control of types of schizophrenia tested; and (5) no control of accessibility of the subjects.[26,20,23] We may add the following general considerations: (1) divergent techniques of analysis were employed; (2) the techniques used were too crude to uncover important trends in the data.

Findings in organic disorders, mental deficiency, manic-depres-

*The important studies reviewed by them are those by Pressey (35), Wells and Kelley (51), Barnes (3), Wentworth (52), Altman and Shakow (2), Malamud and Palmer (30).

sive psychosis, alcoholic disorders, etc., are also reported [10,42] and are no more conclusive than the findings in schizophrenia.

Summary: All these studies agree that schizophrenia entails selective impairment of proficiency on test items; however, there is little agreement as to which are the items which reflect these specific impairments.

(c) *Psychological Rationale of Findings.* The rationale of a test item is a statement of the psychological function or functions which are tapped by that item. Even if we should observe that specific psychiatric disorders affect the ability to pass specific items, these observations must still be interpreted in terms of impairments of specific psychological functions if they are to be meaningful to the clinical psychologist and psychiatrist. The rationale makes possible the interpretation of test findings and is an integral part of scatter analysis.

Rationales of the Stanford-Binet subtests have for the most part not been explicitly formulated. The rationales given by most investigators are embedded in their inferences regarding the nature of the impairment in a specific psychiatric disorder. Mostly schizophrenics and organics were studied. Only studies dealing with schizophrenia will be considered here.

One group of investigators explains failures as due to inadequate *attention and effort,* poor *control,* or a weakness in *volition.* Most of these are referred to by Hunt and Cofer [20] and Kendig and Richmond.[23] To these may be added Wells and Kelley [51] and Piotrowski.[33] Hunt and Cofer, and Kendig and Richmond support this point of view.* Such very general formulations, however, are in essence an evasion of the problem; they do not systematically relate test items to psychologically meaningful functions and concepts and are of little practical clinical use.

Another group of investigators refers to the loss of specific but broad capacities.[20] The various capacities referred to include: (1) *the capacity to generalize and think conceptually,* reflected on similarities, defining abstract words, interpretation of fables, and sentence construction;[40,52,13] (2) *judgment,* reflected on comprehension, interpretation of fables, detecting absurdities, ball and field, and problem questions;[52,30,40,13] (3) *ability to understand motives underlying social acts,* reflected in interpretation of fables, compre-

*Hunt and Cofer claim that selective scatter in schizophrenia reflects a "defective motivation and control of performance" rather than a "loss of fundamental capacities". Although they recognize the importance of "past experience, present motivation, etc." they still adhere to the classical concept of "capacity" as a basic attribute of the mind, a position which is rejected by Rapaport, Gill and Schafer (39) and by Machover (27).

hension, and detecting absurdities;[52] (4) *visual discrimination and visual recognition,* reflected in copying a diamond, and memory for designs;[40,13,32] (5) *memory and recall,* reflected in repetition of digits, repetition of sentences, memory for designs, and reading and report of a paragraph.†[13,31]

Systematic classifications of test items in terms of rationale were made by Wells,[50 p. 53] Kendig and Richmond,[23 p. 54] and Roe and Shakow.[42 p. 377] Wells set up his categories as follows: *speed* (some of the items included were: naming 60 words, dissected sentences, arithmetic, problems of enclosed boxes); *vocabulary; memory* (repetition of digits, repetition of syllables, reading and report of paragraph); *imagery* (memory for designs, problem of enclosed boxes); *comparisons* (similarities, differences); *reasoning* (arithmetic, induction test); *comprehension; practical judgment* (ball and field); *ideational judgment* (detecting absurdities, interpretation of fables, problem questions); *sensation* (comparison of weights); *perception of form* (copying a square or diamond). Kendig and Richmond's categories are: *mainly eductive* in which "g" ("general intelligence") is supposed to play the leading role (vocabulary, comprehension, problem questions, interpretation of fables, etc.); *mainly non-eductive* in which factors other than "g" are preponderant (memory, visual imagery, orientation). Roe and Shakow, who offer the most systematic and meaningful classification attempted, establish the following categories: *remotely learned—vocabulary* (vocabulary, definition of abstract words); *remotely learned—other* (date, months, counting 20-0, etc.); *immediately learned* (repetition of digits, repetition of syllables, designs from memory, reading and report); *associative thinking—immediate* (comprehension, picture description, picture interpretation); *associative thinking—sustained* (ball and field, problem questions, finding rhymes, sentence construction); *conceptual thinking* (detecting absurdities, interpretation of fables, similarities, differences, problem questions, induction).

Finally, the rationale offered by Terman [46] for each test item, although not systematically formulated, is most suggestive. Thus, the *ball and field* item is said to refer to practical judgment; *rhymes* call for the finding of verbal associations under the direction of a

†Several writers recognize that impairment on "memory" tests refers, to some extent at least, to a weakness of attention. Myers and Gifford indicate that not all "memory" tests measure the same thing. They state that their findings "cut directly across traditional psychological categories in that, while 'memory' for word meanings, sentences, and digits remains relatively unimpaired (in schizophrenia), 'memory' for stories and designs is seriously reduced."

guiding idea which inhibits irrelevant associations; *absurdities* call upon judgment, or a critical faculty (poor judgment occurs when "ideas do not crosslight each other, but remain relatively isolated and so not irreconcilable") ; in *memory for designs* there is an analysis of the visual impressions, and the creation of a meaningful whole which facilitates memory of the material; *interpretation of fables* necessitates a generalization of the concrete, as well as social consciousness; ability to solve the *problem questions* depends on the number and logical quality of the associations with each of the given elements separately, and upon the readiness with which these associations are yielded up and woven into some kind of unity; *arithmetical reasoning* requires ready and accurate application of knowledge already possessed to the problems given.

Summary: It appears that there is even less agreement as to the nature of the impairments indicated by failure on specific test items than was found regarding the items on which schizophrenics were most likely to fail. The rationales offered have been inadequate because they have been broad generalizations, couched in vaguely defined terms. Beyond this, however, the rationales have in no case been validated, and in no case have they been integrated into any theoretical psychological framework which would make possible not only a systematic validation but also an extension of the analysis of selective scatter to non-psychotic groups.

We may conclude that the many studies of scatter on the Stanford-Binet have, at best, borne only inconclusive results.

2. Scatter in inter-test comparisons — the "psychometric pattern" approach.

Rather than study the success and failure on single items as was done with the Stanford-Binet, investigators using the psychometric pattern" approach compared scores obtained on two or more different tests (usually a verbal test and performance test). This approach has brought more consistent and more significant results than were obtained with the Stanford-Binet.

Studies on psychometric patterning have been reviewed by Bijou. Related studies are reviewed by Brody, and Hunt and Cofer.

Brody (10 p. 239) reviewed investigations in which performance tests were compared with verbal tests.* There was general agreement that psychiatric patients (especially psychotics) were less proficient on the performance than on the verbal tests.

*Outstanding among the papers reviewed are those by Hollingworth (substitution test), Micheals and Shilling (Porteus maze test), and Kent (Koh's Block Test).

Hunt and Cofer [20 p. 988] reviewed some studies by English factor analysts who attempted to study scatter in terms of Spearman's factors: general ability (g), preservation (p), fluency (f), will (w), and speed (s). These investigators found that manics low in "g" were high in "f". Depressives had "f" scores relatively lower than "g" scores. Schizophrenics with very high "p" scores were relatively inaccessible. The scores changed with changes in the patient's clinical condition. "P" was abnormally high in both manic and depressed patients. Cases with hysteria showed consistently low "f" scores. These results are interesting but need to be related to the phenomenology and psychiatric understanding of the various disorders.

Bijou's [4] review summarized studies on psychometric patterns of psychotics, habitual criminals, adolescent delinquents, mental defectives and school children. These dealt mainly with the relationship between performance and verbal scores.

Psychotic patients regardless of diagnosis showed the same general pattern: highest score on Terman vocabulary, second highest on Stanford-Binet, lowest on any of the performance tests employed. This pattern did not prevail in non-psychotics and tended to disappear in psychotics who improved after insulin treatment.† Bijou‡ found the same pattern to hold for habitual criminals. This pattern was attributed to inadequacy in performance on tests "scored as strictly as possible" on the basis of time, accuracy, and relevance,[9 p. 10] and was considered to be an indication of poor "behavior efficiency".

Most delinquents and mental defectives exhibited a strikingly different pattern, namely: low vocabulary and Stanford-Binet scores with relatively high performance I.Q.'s* Those with low performance I.Q.'s were shown to be most unstable and least likely to make an adequate social adjustment.† Thus, it appears that among mental defectives and adolescent delinquents, as well as in psychotics, a relatively low performance quotient is a serious indication of poor "behavior efficiency".

This psychometric pattern was shown to be an indicator of "behavior efficiency" in maladjusted children also.‡ Those children with "psychomotor ability" considerably higher than "verbal ability" were referred to the mental hygiene clinic mostly for delinquent behavior; children with "psychomotor ability" lower than "verbal

†Jastak 1937, 1939.
‡Bijou 1939.
*Glanville 1937, Bijou 1941, Kinder and Hamlin 1937, and Johnson and Fernow 1939.
†Hamlin 1938, Earl 1940.
‡Uhler 1937.

ability" were referred to the clinic mostly with psychosis, schizoid reactions and emotional instabilities.§

Other papers not included in Bijou's review support these findings. Bijou [8] and Bijou and McCandless [9] showed that mentally defective children with low performance I.Q.'s were the most poorly behaved, most unstable, and least likely to adjust adequately in the training school situation, while among those who were paroled, the children with the relatively superior performance I.Q.'s made the better life adjustment.

Piotrowski [33] showed that schizophrenic children did poorly on performance tests whereas congenitally defective children did poorly on verbal tests.

However, not only from a disparity between verbal and performance I.Q.'s can the level of "behavior efficiency" be inferred. Jastak [22] and Bijou [5,6] report that a disparity between arithmetic achievement scores and reading achievement scores apparently has the same significance as the disparity between performance and verbal I.Q.'s. Bijou showed that use of the two patterns together makes possible a more accurate prediction of "behavior efficiency". Earl [14] demonstrated that a discrepancy in scores on two verbal tests or on two performance tests can also be used as an indication of emotional instability.

A study not clearly related to the others reported in this section, but pertinent to psychometric patterning, is that carried out by Hunt and Older,[21] who administered a battery of four short verbal tests, two written and two oral, to groups of naval recruits diagnosed as psychopathic personalities, cases with organic involvement, and schizophrenics. They found that the psychopaths were distinctly better on the written than on the oral tests. There were significantly more neuropsychiatric discharges among cases with "inter-test variability of more than two years in mental age" than among those with a scatter of less than two years.

Summary: These studies establish the usefulness of the psychometric pattern approach. Poor "behavior efficiency" may be predicted from psychometric patterns. However, the concept of "behavior efficiency" is in need of precise definition. Without such definition it remains too gross to be of full value to the clinical psychologist called upon to make differential diagnoses.

§That most delinquents have good "behavior efficiency" should perhaps be explained. Jastak (56 p. 111) makes it possible to understand this when he states that, "Arithmetic and performance tests measure attentional control, effectiveness of concentration, practical adaptability, relevance of judgments, orderliness of thought processes, and contact with reality." These functions are relatively intact in delinquents but quite impaired in psychotic patients.

3. Wechsler-Bellevue Intelligence Scale.

Further progress in scatter analysis might have been long delayed were it not for the advent of the Bellevue Scale. This test retains the merits of the psychometric pattern approach in that the examiner may compare a vocabulary score, a verbal I.Q. and a performance I.Q. It is an advance over the psychometric pattern approach in that it includes a wide variety of items, grouped into eleven homogenious subtests, with scores on all of these subtests equated so that many more test score interrelations could be studied.

(a) *The first evaluations of scatter.* The first study of scatter on the Bellevue Scale was reported by Gilliland in 1940.[15] He found scatter to be 35% greater in psychotics than in normals and, tracing subtest inter-correlations, he concluded that there were also pattern differences between the two groups.. In a subsequent study, Gilliland, Wittman, and Goldman [16] determined (1) the significance of differences between mean weighted scores of various clinical groups* on each subtest, and (2) the significance of differences in amount of intra-test variance. In this study they obtained no significant results and concluded that there was no difference between the "pattern of intelligence" of psychotic patients and normals. Weider,[49] also studying differences in mean weighted scores, showed that young schizophrenics were significantly less proficient on the Digit Symbol subtest than were normals; older schizophrenics were less proficient than normals on Digit Symbol, Object Assembly, and Picture Arrangement. The limitation of these investigations was that they attempted to study scatter after first averaging the scores of a large group of patients on each subtest. That this method of analysis is too gross and can do little more than establish the most obvious trends in the data is demonstrated by the fact that the data of both Gilliland and Weider contain, in addition to those pointed out by them, many trends which were shown to be significant by other investigators who used more precise methods of analysis. It should also be noted that these studies do not deal with scatter patterns; they measure impairments on individual subtests, rather than test-score *inter-relations.*

The next advance in scatter analysis was made by Rabin.[37] He ranked the sub-tests in order of magnitude of the mean weighted scores and compared the patterns thus obtained from a group of schizophrenics and a group of nurses.† Rabin then devised a "Schizo-

*Schizophrenics, paretics, manics, psychoneurotics, drug and alcohol psychoses, mental defectives, and a control group.

phrenic Index" which was the ratio of Information + Comprehension + Block Design to Digid Symbol + Object Assembly + Similarities. This index successfully differentiated his schizophrenic group from his neurotic and normal groups, and in a later study (38) from a manic group. However, since Rabin's index was not composed of those subtests which were *most* diagnostic of his schizophrenic group,‡ and since there is no rationale for the index as a whole, its significance as a measure of the schizophrenic *test pattern* remains questionable. Furthermore, the use of an index of this sort is not only too rigid and mechanical a tool for the clinical psychologist, but may encourage one to neglect seeking for the meaning of selective scatter.

Machover (27) in a study seeking differentiation between southern—northern, white—negro, and criminal—non-criminal groups used a method which resembles Rabin's "index" in that many subtest scores are converted into a "compound-score". Machover by means of regression equations was able to differentiate significantly the three pairs of groups.

Summary: These earlier studies of scatter on the Bellevue scale proved promising but the techniques used were gross and did not exploit the many subtest-score interrelations which in later studies, proved to be significant.

(b) *More precise methods of scatter analysis.* With the growing realization that more precise methods were necessary in the study of selective scatter, investigators turned from observations of inter-test variability based on group means, to measures which could reflect the relationship between subtest scores of *each individual* in a group. The first such measure was suggested in 1941 by Brown, Rapaport, et. al.(12) These investigators determined the deviation of each of an individual's subtest scores from the mean of all of his subtest scores; they computed also the deviation of each of his verbal subtest scores from his verbal mean and each of his performance subtest scores from his performance mean. The mean deviation scores of schizophrenic, neurotic, depressive, and character disorder groups on each subtest were compared. This method proved

†The rank order of mean subtest scores found by Rabin (36) and by Magaret (28) were compared by Weider (49) with the rank order of mean scores of his groups. His results support Rabin in pointing out that schizophrenics obtain relatively high scores on Information and Comprehension, and relatively low scores on Object Assembly as compared to their other subtest scores. His results differ from Rabin's and support Margaret's in the conclusion that Arithmetic scores are relatively low in schizophrenics. All agree that the lowest scores are obtained on Digit Symbol.

‡Schizophrenics were relatively more proficient than normals on Information and Arithmetic, and were relatively less proficient on Object Assembly and Digit Symbol.

fruitful and was used in conjunction with other methods of analysis in a more extensive investigation [39] which shall be described in section (c).

The next reference to the deviation of a subtest score from the mean of all of an individual's subtest scores was made by Wechsler [48] in the second edition of his test-manual, where for the first time he summarized the clinical impressions gained while observing intra-individual variability.* He reports that schizophrenics score highest on Vocabulary and Information, and lowest on Digit Symbol and Object Assembly. Comprehension, Similarities, and Picture Completion scores may or may not be low, depending on the type of schizophrenia.

Using this deviation measure, Magaret [28] found, as did Brown, Rapaport, et. al.,[12] that schizophrenics scatter more than non-psychotics. Specifically, their Vocabulary and Information scores were significantly more above, and their Digit Symbol and Comprehension scores significantly more below, the mean than was the case with the non-psychotics. In a later paper, Magaret and Wright [29] demonstrated significant differences between schizophrenics and mental defectives in the deviation scores on several subtests.

Rabin [38] used this measure in a recent study. An inspection of his data reveals a pattern of mean deviation scores in schizophrenics similar to that obtained by Magaret. This pattern was especially clear in patients who were retested about a year after they were admitted to the hospital.

Summary: *It appears that consistent and statistically significant results are obtained by various investigators when intra-individual measures of scatter are used.*

(c) *Use of a combination of measures.* Finally, the attempt to exhaust the diagnostic possibilities of the analysis of subtest score variability led to the use of a combination of intra-individual measures of scatter. This procedure was first suggested by Wechsler.[46b] The measures he recommended included: (1) verbal minus performance score, (2) deviation from the mean subtest score, and (3) specific subtest score inter-relations. The first published study demonstrating the advantage of using a combination of measures was done by Levi,[25] who attempted to differentiate adolescent psychopaths from non-psychopaths. He found that among the psychopaths there was a significantly greater percentage of cases with (1) perform-

*These appear for the first time in the second edition of his book, and though presented in more detail in the third edition, they undergo little change.

ance I.Q. eleven or more points above verbal I.Q., and (2) Picture Arrangement + Object Assembly scores higher than Picture Completion + Block Design scores.

Several measures of subtest interrelations were used in an extensive investigation conducted by Rapaport, Gill and Schafer,[39] and reported briefly by Schafer and Rapaport.[44] The measures described were: (1) vocabulary scatter, (2) modified mean scatter, (3) inter-subtest comparisons, and (4) percentage of cases in each group with very high or very low weighted scores. These measures successfully differentiated most of the nineteen different clinical groups* from each other and from three normal control groups. Using the combination of these measures, it was possible to differentiate most of the clinical groups. The findings are too extensive to be adequately reported in this review, but it should be stated that the study clearly indicates that patterns of subtest scores differ in different types of schizophrenias, depressions, and neuroses.

Summary: It is safe to conclude that the use of a combination of intra-individual scatter measures has made possible more precise diagnosis of psychiatric disorders and has made possible the extension of scatter analysis to non-psychotic patients.

(d) *Rationale of Subtests.* The need for a rationale, or statement of psychological functions tapped by the test items, has already been indicated in reviewing the Stanford-Binet literature. A rationale makes possible the *interpretation* of scatter patterns which are observed. In addition, however, it makes scatter analysis a flexible tool instead of a rigid and mechanical procedure dependent upon diagnostic "signs" and unable to cope with deviations from "typical" scatter patterns. Deviations from "typical" patterns reflect the individual differences which exist between patients in any clinical group; they can be understood, and hence can contribute to a more exact diagnosis, only if one keeps in mind the "meanings" of subtest scores.

The first statements about functions tapped by the subtests of the Bellevue Scale was given by Wechsler in 1939 [48a] but appeared only as scattered comments in the description of the subtests themselves. No systematic rationale is given in either his second or third editions although some rationale is offered in relation to the scatter in specific psychiatric disorders.

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*Acute, chronic and deteriorated schizophrenias of both paranoid and unclassified types; paranoid conditions; simple schizophrenias; preschizophrenias, both "coarctated" and "over-ideational"; psychotic, involutional, severe neurotic, and neurotic depressions; hysteria; obsessive-compulsives; mixed neurosis; neurasthenia; and neurosis with anxiety and depression.

Magaret [28 p. 523–527] felt the need to account for the pattern of successes and failures which she observed in schizophrenics. She showed that neither time limits on some of the tests, nor the differential effects of motivation could account for the patterns which were observed. She drew no positive conclusions.

Machover [27 p. 60ff] offered some rationale to account for his findings but did not present a rationale for each of the subtests.

Rabin refers only to impairment of "alertness and speed of association",[38 p. 88] and to "initiative in seeking and achieving an unknown goal".[36 p. 100]

The most systematic attempt at a rationale was made by Rapaport, Gill, and Schafer.[39]* On the basis both of theoretical psychological considerations and an examination of which impairments observed clinically in patients may correspond to impairments evident in their psychological tests, a rationale of all the subtests was developed and to some extent validated by these investigators. It is possible to mention only briefly their conclusions: *Comprehension* they consider to indicate "judgment"; good performance in *Arithmetic* and *Picture Completion* depends mainly upon unimpaired "concentration"; the *Digit Span* score indicates the efficacy of "attention"; *Block Design, Object Assembly,* and *Digit Symbol* call upon "visual-motor coordination"; the *Digit Symbol* score is also an indication of "psychomotor speed"; the information test is a test of "memory" for knowledge gathered by the patient in everyday life; *Similarities* reflect "verbal concept formation"; *Picture Arrangement* requires "visual organization" and is a test of "anticipation".

Summary: A start has been made in the development of a rationale for the subtests of the Bellevue Scale. It is hoped that the growing appreciation of the need for a satisfactory rationale will result in the further development of this fundamental facet of scatter analysis.

Summary and Conclusion

For 35 years psychologists have tried to prove that scatter on intelligence tests may be related to mental disorders. The investigations of scatter on the Stanford-Binet test were inconclusive. Investigators who used a battery of tests rather than the Stanford-Binet alone did, however, meet with a measure of success. The Wechsler-Bellevue Scale combined the merits of the previous tests

*The fragmentary beginnings of this rationale were presented by Brown, Rapaport, et al. (12), and a brief outline and description of it was reported by Reichard and Schafer **(41)**.

used and eliminated many of their shortcomings. With the use of this test, with the aid of new and more precise methods of analysis, and with the development of sub-test rationales, the value of scatter analysis for the clinical psychologist has been demonstrated.

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Observations on Abnormal Anatomy of a Two-Headed Calf

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From a review of the literature, it would seem anomalies have always been popular objects for study. Bremer (1944) has given a good review of the literature since 1711 on intestinal diverticula and duplications of the digestive tract. Gier (1931) reported to this Academy on the circulatory system of a two headed calf. Stiles (1939) listed many anomalies found in a double monster calf. The present study describes part of another such calf.

This calf was delivered by cesarean section on the farm of Grover Albright, Kearney, Missouri, May 5, 1944. The cow died. The calf was brought to us on May 7, apparently still in a good state of preservation. It was planned at that time to mount the skin for a museum exhibit. Upon examination the same afternoon, however, the hair was found to be slipping and the internal organs were not in

FIG. 1. Median hind leg and part of thoracic structure (split along main sternum)
A. dextral vertebral column
B. sinistral vertebral column
C. median hind leg (with two feet attached)
D. main sternum
E. cartilage secondary sternum

good condition. We decided to dissect the animal as far as possible to determine the amount of duplication of organs and their stage of development.

The calf was apparently full term. It had two heads, two vertebral columns (A & B, Fig. 1), and two tails. There were four normal legs and also a fifth, median, hind leg (C) with two well developed feet. This last leg had been cut off and the posterior part of the body badly cut up by the attending veterinarian. There was a single umbilicus with a normal set of tubes. The calves were apparently both female.

In this type of twinning, I am choosing to speak of the right foetus as the dextral and the left as the sinistral foetus although it is recognized that neither is a complete foetus.

The dextral foetus had a right series of ribs and the sinistral had a left series, all completely formed, normal in number, and attached to a common sternum (D). The ribs formed mesially on the other side of each of the respective vertebral columns were shortened, reduced in number, and connected to a cartilage sternum (E). The shafts of the mesial, sinistral series were shortened more than those of the dextral. The sinistral column was broken between the first and the second thoracic vertebrae. The pelvis was partly missing but there was no indication that the fifth leg had been attached to it.

The thymus glands and the lungs were disintegrated. There were two tracheae. There was only one heart. It lay in the sinistral thorax. The blood vessels were badly decomposed so were not traced. However, the dorsal aorta bifurcated posterior to the anterior mesenteric artery, forming two dorsal aortae. The sinistral diaphragm was undeveloped. The left kidneys of both foetuses were more lobed than the right kidneys. There was a single imperfectly developed spleen. There were two livers, the dextral one being normal excpt for two gall bladders, while the sinistral one was represented by a single lobe which protruded into the thorax.

Each foetus had a stomach with a normal oesophagus. The dextral stomach lay anterior to the diaphragm and was connected to the intestine. The sinistral stomach was in a normal position but ended as a blind pouch. There was a great mass of intestine (A, Fig. 2). The length of intestine was not determined because of the state of decomposition. The intestine forked at the end of the ileum (B) and each intestine entered a separate colon (C & D), each of

which connected to an anal aperture. About four inches from the fork, there was a branch from each colon, which united to form a caecum (E). This, to us, was the most interesting anomaly found, mainly because the decomposition had not progressed so far as to prevent following out the structure.

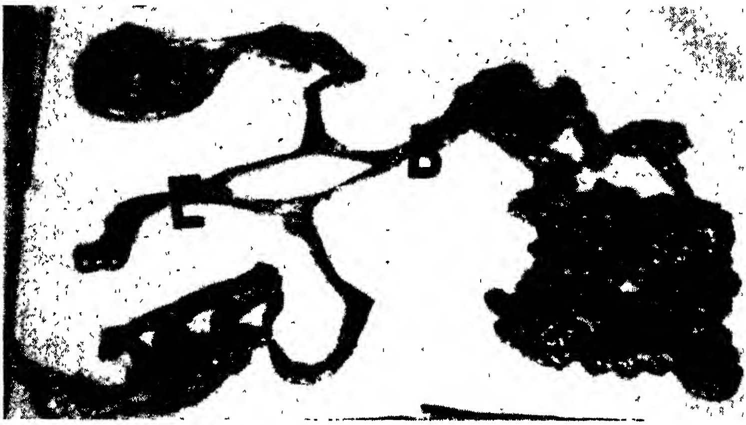

FIG. 2. Part of the digestive system of the calf.

a. mass of small intestines
b. posterior end of ileum
c. colon of one animal
d. colon of other animal
e. common caecum

We are grateful to Mr. Albright for allowing us to make this study and take this opportunity to acknowledge our indebtedness to him.

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Rodent Activity in a Mixed Prairie Near Hays, Kansas*

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This study was conducted to determine the activity of rodents in connection with the utilization of native plants on a mixed prairie in western Kansas.

The mixed prairie near Hays, Kansas was segragated by Albertson[1] into three types. The big bluestem dominates the ungrazed lowlands and ravines. Little bluestem and its associates are most common on the hillsides, while the short grasses occupy the high level land.

Riegel[7] during the fall and winter of 1939 and 1940 observed spermophiles feeding on cactus seeds and burying the seeds in the ground in caches. Seedlings of prickly pear were found emerging from these buried stores.

Unpublished data by Wooster[12] estimated that during that year there were approximately 7367 *Microtus,* 1251 *Peromyscus* and 1529 *Reithrodontomys* per square mile (640 acres) near Hays, Kansas on the college pasture and adjoining areas. Studies on the effect of drouth on animal population in western Kansas were made by Wooster[10-11] and the*Microtus* decreased from 2500 per square mile to a point where no signs of their activity could be detected.

The identification of rodents and rabbits by their fecal pellets was made by Webb[9] at Fort Hays State College, Hays, Kansas. This information was valuable in organizing data collected for this manuscript in determining food habit studies of the rodents.

Methods of Study

The area selected for the investigation contains approximately 550 acres of range land in or near the college pasture about 2.5 miles west of Hays, Kansas. The vegetation was classified into the six following habitats:

Short grass	Grazed little bluestem
Natural revegetation	Ungrazed little bluestem
Artificial revegation	Big bluestem

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*Contribution No. 54, Dept. of Zoology, Fort Hays, Kansas State College.

Early in the fall of 1944 the vegetation types were selected and studies were carried on throughout the fall and winter.

Traps were used on representative areas to determine the abundance of each rodent species. The number of mice was found by arranging 24 mouse traps in a gridiron pattern on an acre of each type of vegetation for seven days each month. The traps were baited with a mixture of peanut butter, raisins, grains, grass and forb seeds. Several areas also were studied for a period of three months with unbaited traps to compare the catches made with baited traps on similar areas.

Much data on food habits, nest materials and home life were gathered by excavating burrows and caches.

The species of plants, of which the seeds, stems, or leaves were stored in nests, burrows or caches, were assumed to be those utilized in some manner by rodents. When recently deposited fecal pellets were found near partly eaten vegetation, it was assumed that these plants were utilized by the rodents that deposited the pellets.

A harvest mouse and a white-footed mouse were caged for a week with a mixture of grains, grass and forb seeds and several species of insects to determine the amount and variety of the diet which they selected.

Table 1.

The grasses, forbs and shrubs found to be most important as aids in the identification of native rodents.

Common Name	Scientific Name
	Grasses
Big bluestem	*Andropogon furcatus*
Blue grama	*Bouteloua gracilis*
Buffalo grass	*Buchloe dactyloides*
Green foxtail, green bristlegrass	*Setaria viridis*
Hooker's dropseed	*Sporobolus hookeri*
Indian grass	*Sorghastrum nutans*
Little barley	*Hordeum pusillum*
Little bluestem	*Andropogon scoparius*
Sand dropseed	*Sporobolus cryptandrus*
Side-oats grama	*Bouteloua curtipendula*
Switch grass	*Panicum virgatum*
Western wheatgrass	*Agropyron smithii*
Windmill grass	*Chloris verticillata*

Forbs and Weeds

Blazing star	*Liatris punctata*
Broomweed	*Gutierrezia sarothrae*
Cactus, Prickley pear	*Opuntia macrorrhiza*
Chalk lily	*Nuttallia decapetala*
Cocklebur	*Xanthium commune*
Common sunflower	*Helianthus annuus*
Ironweed	*Veronia interior*
Ivory-seeded borage	*Onosmodium occidentale*
Low milkweed	*Asclepias pumila*
Mares tail	*Leptilon canadense* or *Erigeron canadensis*
Maximilian sunflower	*Helianthus maximiliani*
Perennial ragweed	*Ambrosia psilostachya*
Pitcher sage	*Salvia pitcheri*
Prairie alfalfa	*Psoralea tenuiflora*
Prairie coneflower	*Ratibida columnaris*
Rocky Mountain bee bush	*Cleome serrulata*
Russian thistle	*Salsola pestifer*
Sensitive brier	*Morongia uncinata*
Single fruited croton	*Croton monanthogynus*
Snow-on-the-mountain	*Euphorbia marginata*
Soapweed	*Yucca glauca*
Texas croton	*Croton texensis*
Wavy-leafed thistle	*Cirsium undulatum*
Whitlow wort	*Paronychia jamesii*
Wild onion	*Allium nuttallii*

Trees and Shrubs

American elm	*Ulmus americana*
Buckbrush	*Symphoricarpos orbiculatus*
Chokecherry	*Prunus melanocarpa*
Hackberry	*Celtis occidentalis*
Ill-scented sumac	*Rhus trilobata*
Prairie rose	*Rosa suffulta*
Smooth sumac	*Rhus glabra*

Results

Only native rodents found to be important in the utilization of native plants were considered in this problem.

The white-footed mouse (*Peromyscus maniculatus nebrascensis* Coues) and the gray harvest mouse (*Reithrodentomys montanus griseus* Baird) were present on all six plant types.

The prairie harvest mouse (*Reithrodentomys megolantis duchei* Allen) was found on the artificial revegetation and ungrazed little bluestem, while the spermophile (*Citellus tridecemlineatus arenicola* A. H. Howell) was limited to the short grass, natural revegetation and artificial revegetation types. The pocket mouse (*Perognathus hispidus paradoxus* Merriam) and wood rat (*Neotoma floridana campestris* Allen) were seen on only the grazed little bluestem area. The meadow mouse (*Microtus ochrogaster haydenii* Baird) was collected on small areas in the artificial revegetation and ungrazed little bluestem types.

The White-Footed Mouse

The white-footed mouse was the most widely distributed and most abundant of the mammals found. It was caught from burrows, open nests, piles of weeds, cactus plants, holes beneath rocks, cracks in banks and from runs of the meadow mouse. The number caught was greatest on the lowland. Least activity was found on the short grass and artificial revegetation types (Table 2).

A fire destroyed the vegetation on the natural revegetation area in November. Immediately the catches increased as compared to catches before the fire.

Calculation from trapping records showed approximately 3232 white-footed mice per square mile.

Table 2. Number of White-Footed Mice Caught on Each Habitat

Habetat	*Sep.*	*Oct.*	*Nov.*	*Dec.*	*Jan.*	*Feb.*	*Mar.*	*Total*
Artificial Revegetation	3	4	3	4	3	3	2	22
Natural Revegetation	1	1	fire	4	3	8	9	26
Short Grass	2	1	0	11	1	0	2	17
Big Bluestem	6	4	3	11	9	5	12	50
Grazed Little Bluestem	1	3	4	14	10	5	2	39
Ungrazed Little Bluestem	2	1	2	3	12	13	5	38

Baited traps failed to increase the number of the white-footed mouse caught; in fact the largest catches (32 in comparison to 28) were made in those unbaited.

Caches of stored seeds and pellets near freshly eaten plants indicated that 24 different species, of which 7 were grasses and 17 were forbs, furnished some food for these animals.

The short grass and grazed little bluestem areas furnished 11 plant species for food. The common sunflower was most heavily utilized, also buffalo grass and cactus seeds were extensively eaten. Cow dung and pheasant droppings were an important part of their diet when most vegetation was blanketed with snow. It was evident that the mice were seeking the seeds found in the droppings. Evidence from excavated burrows showed that much of the diet of this mouse consisted of crickets, beetles, moths, spiders, millipedes and

grasshoppers. The latter two were found throughout the winter on sunny days even when most of the ground was covered with snow. A mouse was brought to the laboratory and at the end of the week it had eaten 88.2 grams of insects as compared to 11.6 grams of mixed grains and seeds. Insects, especially grasshoppers, were preferred to grains and seeds of native plants.

Nests were constructed mainly of the leaves of grasses, preferably blue grama and buffalo grass forming the outer portion of the nest intermixed with little barley, side-oats grama and big bluestem. The inner lining of the nest was usually of the leaves of sand dropseed and the pappus from milkweed and wavy-leafed thistle. The less common plants used as nest material were common sunflower, perennial ragweed, and Hooker's dropseed. Hair and feathers were found in the lining of several nests.

Nowhere in literature has the author found any reference to winter breeding in Kansas of any species of the white-footed mouse. Gravid females were caught throughout the fall and winter, the number of embryos per gravid female varied from 2 to 5, with an average of 3.64. In September 57.14 percent of the females caught were gravid, but the number decreased to 4.76 and 3.57 percent, respectively, in December and January, and then increasing to 35.3 percent in March.

Possibly the winter breeding activity was caused by the temperature which was considerably above normal throughout the study. At no time was the mercury below 4 degrees above zero Fahrenheit during the fall and winter months.

The Harvest Mouse

Two species of harvest mouse were caught on the area, the most common being the little gray harvest mouse, the smaller of the two species, which was found on all plant habitats, whereas the prairie harvest mouse occurred only on the artificial revegetation and ungrazed little bluestem where a thick cover of grasses was maintained.

Largest numbers of the harvest mouse were caught during the winter months on the artificial revegetation and the lowland types (Table 3). Natural revegetation had a fair population of these mice until after a fire in late November. The number was slightly less on the short grass and ungrazed little bluestem, but only one specimen was taken from the grazed little bluestem.

It was estimated that there were about 1766 harvest mice per square mile.

TABLE 3. NUMBER OF HARVEST MICE CAUGHT ON EACH HABITAT

HABITAT	*Sep.*	*Oct.*	*Nov.*	*Dec.*	*Jan.*	*Feb.*	*Mar.*	*Total*
Artificial Revegetation	2	2	4	3	4	20	5	40
Natural Revegetation	4	4	3	Destroyed by fire				11
Short Grass	2	2	3	2	1	7	3	20
Big Bluestem	1	3	4	7	7	1	2	25
Grazed Little Bluestem	0	0	0	0	0	0	1	1
Ungrazed Little Bluestem	1	1	0	0	8	6	3	19

The nest of this mouse was a ball of grass leaves with an opening in the side. It was generally suspended a few inches from the ground in the taller grasses or sometimes placed on the ground or in tin cans or other objects on or near the ground. Such grasses as big and little bluestem, blue grama and side-oats grama formed the bulk of the nest material, the inner lining being of sand dropseed and the pappus from the low milkweed and wavy-leafed thistle.

Grasshoppers and the seeds of buffalo grass and switch grass made up most of the diet of this rodent, but Indian grass, crowns of blue grama, and the flower heads of brown weed, iron weed, snow-on-the-mountain and Maximilian sunflower were often utilized.

The cactus fruit and seeds were also eaten on the areas where it was found.

Forty-one mice were caught with baited traps as compared to 16 with the unbaited ones. Gravid females were taken during all months of the study except December and January.

THE MEADOW MOUSE

The meadow mouse, the most abundant rodent in much of the native prairie several years ago, was found only in small areas in the ungrazed little bluestem and the artificial revegetation types where a heavy growth of western wheatgrass was intermixed with other midgrasses. On the natural revegetation type, 82 skulls of meadow mice, that evidently had been dead for a year or more, were found on an area approximately six acres in size after the vegetation was destroyed by a fire. It was estimated that there was approximately 22 meadow mice per square mile during the progress of this study.

Plants stored in burrows for food, listed in the order of abundance, were the stems and crowns of western wheatgrass, little barley, buffalo grass, blue grama, side-oats grama, and perennial ragweed. Nests were made from grasses, of which side-oats grama, western wheatgrass and little barley were most important, intermixed with smaller amounts of blue grama, buffalo grass and sand dropseed.

THE POCKET MOUSE

Only three pocket mice were caught and they were found in the grazed little bluestem type near the brows of hills where limestone was exposed. The entrances to the burrows were plugged with fresh

dirt and it was difficult to excavate the holes as they went down into the cracks of the rocks near the surface.

The following seeds were collected from the pockets of the mice: bee bush, snow-on-the-mountain, perennial ragweed, ivory seeded borage, prairie alfalfa, Pitcher sage, single-fruited croton, sensitive brier and Texas croton. Beneath a small rock a cache of 313 seeds was found containing approximately the same species as the above named plants.

The Spermophile

The spermophile was found on the short grass, natural revegetation and a small portion of the artificial revegetation types. The animal went into hibernation about October 21 and was first seen in the spring on March 5. Stored food was taken from several burrows and caches and the most common plants represented were buffalo grass burs and crowns, little barley stems and seeds, and wild onion bulbs. Some of the less common plants utilized were blue grama crowns, cactus seeds, roots of blazing star and underground stems of perennial ragweed.

Fragments of grasshoppers, crickets, beetles and spiders were commonly found in the burrow. The nest was a mat-like structure on the floor of an enlarged chamber near the surface of the soil. Little barley was most extensively used as nest material, but blue grama, buffalo grass, sand dropseed, western wheatgrass and windmill grass were occasionally used.

The Wood Rat

Activity of the wood rat was found only in an abandoned stone quarry bordered by shrubs which furnished food and nest materials. The nest was built upon a burrow leading into some rocks and was constructed from twigs, mostly of chokecherry, smooth sumac, hackberry, elm and ill-scented sumac.

Other plants used in the nest were chalk lily, broomweed, prairie alfalfa, Maxmilian sunflower, Russian thistle and horse weed, with scattered pieces of stones and cow dung.

The food of this animal was mainly seeds of smooth sumac, ill-scented sumac, chokecherry and prairie rose hips. The seeds of soapweed and chalk lily were eaten in small amounts.

The seeds of smooth sumac and ill-scented sumac were taken from the fecal pellets undigested. The percent viability for soil-tested seeds taken from pellets was 14.2 and 23.3, respectively, for smooth sumac and ill-scented sumac.

Rodents As Aids in Plant Dispersal

Seedlings were found growing from caches of buffalo grass and cactus seed buried by the spermophile near the edge of a wheat field bordering the college pasture. Young plants of buffalo grass also were emerging from caches of seed stored by the white-footed mouse.

Germination tests showed that seeds of smooth sumac and ill-scented sumac taken from wood rat pellets were viable, but no seedlings were found growing in the fields.

Summary

The utilization and dissemination of native plants by native rodents on a mixed prairie near Hays, Kansas were studied. If recently deposited pellets were found near plants partly eaten, it was considered that these plants were utilized by the animals depositing the pellets. Also, the presence of leaves, stems, roots and seeds stored in caches or burrows furnished information on food habits of these animals.

The white-footed mouse was found to utilize a total of 24 species of plants, but feeding experiments indicated that, when available, 88 percent of their diet consisted of insects, of which grasshoppers were preferred. The harvest mouse secured food from 11 species of plants. Feeding experiments showed that about 63 percent of its diet was insects when available.

The wood rat and pocket mouse occurred on the rocky hills, whereas the spermophile preferred the short grass, or other types where the vegetation was closely grazed.

The meadow mouse, common to numerous before the great drouth of 1933 to 1939, was found occasionally on areas dominated by midgrasses, especially western wheatgrass. The fact that 82 skulls were collected on six acres indicates that this rodent was recently quite abundant on this area. Wooster in 1931 estimated that there were around 7,367 meadow mice per square mile, whereas now there are approximately 22.

There are now approximately 3,232 white-footed mice and 1,766 harvest mice per square mile. In 1931 Wooster estimated that there were about 1,251 white-footed mice and 1,529 harvest mice per square mile at Hays, Kansas in the college pasture and adjoining areas.

Baited traps failed to increase the catches of the white-footed mouse but did increase the catches of the harvest mouse.

Gravid females of the white-footed mouse were caught during each month of the study from September to March, inclusive.

Seeds of smooth sumac and ill-scented sumac were taken from fecal pellets of the wood rat. Germination tests showed that many of the seeds were viable and that passage through the digestive tract of this animal increased the germination of some of the seeds.

The spermophile and white-footed mouse disseminated the seed of cactus and buffalo grass by storing them in caches, and occasionally young plants were found growing from deposits of this kind.

The burning of the grass on the natural revegetation area increased the catches of the white-footed mouse, whereas catches of the harvest mouse were nil after the burning. Examination of the area indicated that the mice were not burned, but migrated in or out of the area after the fire.

This study indicates that the white-footed mouse and harvest mouse are beneficial to the farmer and rancher in this part of the Great Plains Region, because much of their diet is of destructive insects that feed on native and cultivated vegetation.

Animal numbers vary from year to year, depending upon the ecological factors which benefit or deplete the vegetation that supports them.

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Triangles in the Teeth of the Mammalian Genus Ondatra

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In published accounts of the genus *Ondatra* Link, the triangles of the molars are described as closed. Baird (1857:560) figured and described the M_1 as having a large anterior loop deeply cut by two re-entrant angles, *five closed triangles,* and a posterior loop. M_2 consisted of *four closed triangles,* and a posterior loop. Coues (1887: 252) likewise, but with a different terminology, described the tooth pattern as did Baird. Hollister (1911:14) modified the description of M_1 by writing that the anterior loop was "normally" cut by the re-entrant angles, and followed by five closed triangles. Hinton (1926: 115) pointed out that the immature molars at eruption have open triangles. Nevertheless, Hinton gave triangles closed as a generic character. All the writers cited above described the triangles of the upper molars, with the exception of M_3, as closed.

In an examination of two hundred Recent skulls of *Ondatra zibethicus cinnamominus* (Hollister), the writer found that more than twenty per cent of the animals had open triangles. This condition ranged from a single open triangle above or below to one in which all triangles were open both above and below. The range of variation occurred in all age groups, and in both sexes. Other Recent subspecies additional to *O.z. cinnamominus* were found to have open triangles.

In addition to these Recent forms, Brown (1908:197), Hollister (1911:33), Wilson (1933:132), and Hibbard (1944:732) named as new, and Gidley and Gazin (1938:65), and Hibbard (1943:242) reported fossil forms of *Ondatra* in which the triangles were open. At the time that Hollister (*loc. cit.*) defined the generic characters of the molars, he recognized *O. annectens* (Brown) as a valid species, and described, and named as new, *O. oregonus* Hollister—two fossil species with open triangles. Thus, by implication, he actually redefined one of the generic characters of M_1, and indicated that either open or closed triangles, instead of only closed triangles, were present. It may be assumed that Wilson, Gidley and Gazin, and Hibbard accepted this redefinition inasmuch as they, too, assigned forms with open triangles to the genus.

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Up to now open triangles have received only tacit recognition. Therefore, the writer proposes that the definition of the genus *Ondatra* in the future read in part "triangles open or closed in upper and lower molars."

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ABBREVIATIONS: The following abbreviations for institutions have been used:
U. of K.—University of Kansas.
K.S.C.—Kansas State College of Agriculture and Applied Science.
K.S.T.C.—Kansas State Teachers College.
F.H.K.S.C.—Fort Hays Kansas State College.
Jr.H.S.—Junior High School.
Jr.Col.—Junior College.
U. of W.—University of Wichita.
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*Cincinnati Univ. Library, 1945, Cincinnati 21, Ohio.
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*Wayne Univ. Library, 1945, Detroit 1, Mich.
*Western Reserve Univ. Library, 1945, 11111 Euclid Ave., Cleveland, Ohio.
Wichita City Library, 1932, Wichita.
*Wichita Univ. Library, 1939, 1845 Fairmount, Wichita.

NECROLOGY

The Academy announces with deep regret the death of the following members:

Lillian Aline Phelps

Dr. Phelps, a member of the Kansas Academy of Science since 1941, was born in Kansas City, Missouri, on February 11, 1902. She received her early education and was graduated from high school in that city. She attended the University of Kansas receiving her A.B. degree in 1924 and her M.A. degree in 1925. From the University of Kansas she went to Cornell University from which institution she received her doctorate. While at Cornell, Dr. Phelps taught in the zoology department. She also taught at Hunter College in New York and in a small southern girls' school before coming to Washburn Municipal University in Topeka. Her period of service as assistant professor of biology at Washburn extended from September 1940 to June 1943.

In the summer of 1943 Dr. Phelps received a fellowship in public health at Harvard University. Early in 1944 she became executive secretary of the Oneida County (N.Y.) Tuberculosis and Health Association with headquarters at Oneonta, New York. Her work there dealt with the prevention of tuberculosis, and the care and treatment of tubercular patients, as well as with general health conditions.

Dr. Phelps died in New York City on September 27, 1944 and was buried at Short Hills, New Jersey.

Charles Hazelius Sternberg

Through the death of Charles Hazelius Sternberg on July 21, 1943, a member of the Kansas Academy of Science since 1896, vertebrate paleontology suffered the loss of its dean of pioneer collectors. He was born at Middleburg, New York, on June 15, 1850. His early boyhood was spent in Otsego County, New York, where his father was principal of Hartwick Seminary. In 1865 the family moved to Albion, Marshall County, Iowa, and two years later he, with his twin brother, left home to live with an older brother, Theodore, on his ranch in Ellsworth County, Kansas.

He early became interested in fossil deposits and during his

early youth gathered several hundred specimens of preserved leaves; later more than three thousand specimens were collected for the distinguished paleontologist, Dr. Leo Lesquereux, for the Smithsonian Institution. He disposed of hundreds of leaf specimens to other museums.

Sternberg's first field work for vertebrate fossils appears to have begun while a student at the Kansas State Agricultural College. In 1876 he began his work in the chalk beds in western Kansas and continued his interest in these beds through the greater part of his active career which involved more than 25 separate expeditions. He was absent from Kansas in other fields at intervals, but always returned to carry on in the Niobrara. As a result of these persistent efforts of his and of his sons, large collections from this famous marine formation adorn the shelves and cases of most of the great museums of America and Europe.

In 1882 Sternberg made one of the outstanding discoveries of his career when he found the now famous deposit of rhinoceros (*Teleoceras*) bones at Long Island, Phillips County, Kansas. So great were the number of fossils that he collected here during the seasons of 1883 and 1884 without exhausting the quarry.

No account of Sternberg's life would be complete without mention being made of his contributions to invertebrate paleontology. Through the application of vertebrate field methods he was among the first, if not the first, to collect entire individuals of the very large *Haploscapha* of the Niobrara Chalk. In these same deposits he also collected a large colony of the stemless crinoid, *Uintacrinus socialis*, slabs of which have been widely distributed in this country and abroad. In his declining years in California, he also made many collections of Tertiary invertebrates, including fine specimens of the ammonite *Pachydiscus catarinae*.*

Mr. Sternberg was a frequent contributor to these *Transactions*, his papers appearing in some eleven of our past volumes. He was also the author of three books: *The Life of a Fossil Hunter* (1909); *A Story of the Past* (1911), a book of poems; and *Hunting Dinosaurs in the Bad Lands of the Red River, Alberta, Canada* (1917).*

*For much of the above information on Mr. Sternberg's career, we are largely indebted to the late Mr. Charles W. Gilmore whose more extended biographical sketch of Mr. Sternberg appeared in the *News Bulletin* of the Society of Vertebrate Paleontology Feb. 15, 1944; Miss Edith Larson of Washburn University kindly supplied the biographical information concerning Dr. Phelps.

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